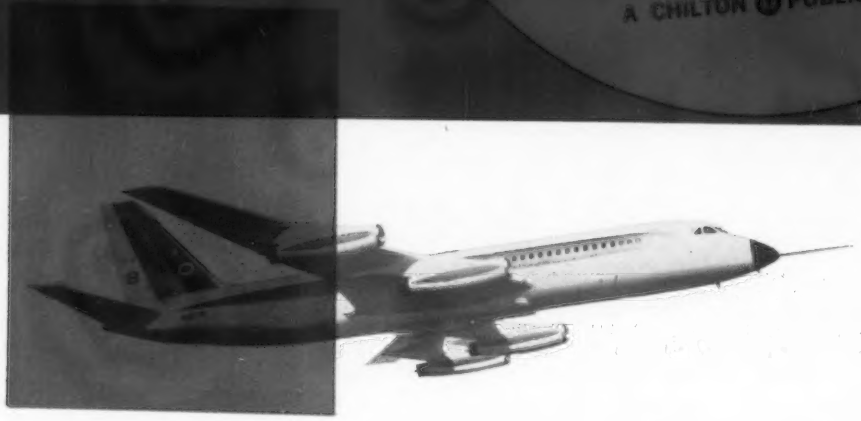
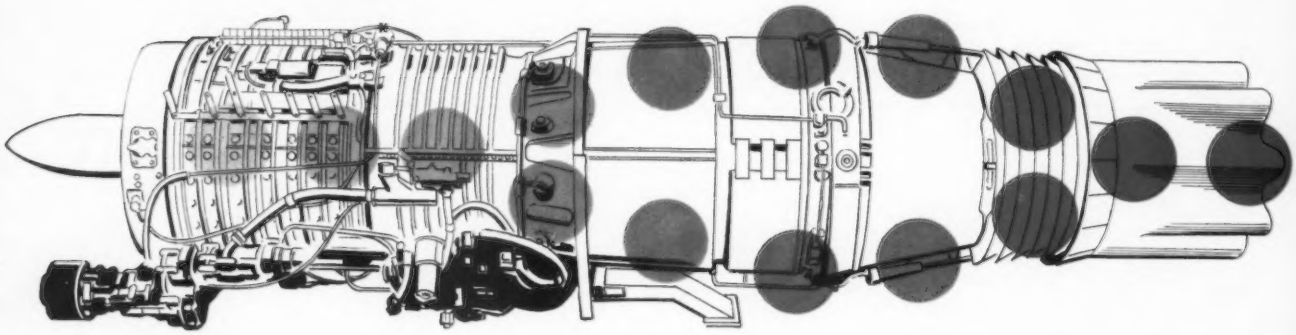
AIRCRAFT AND MISSILES MANUFACTURING

APRIL 1959

A CHILTON PUBLICATION





DESIGN

PRODUCTION

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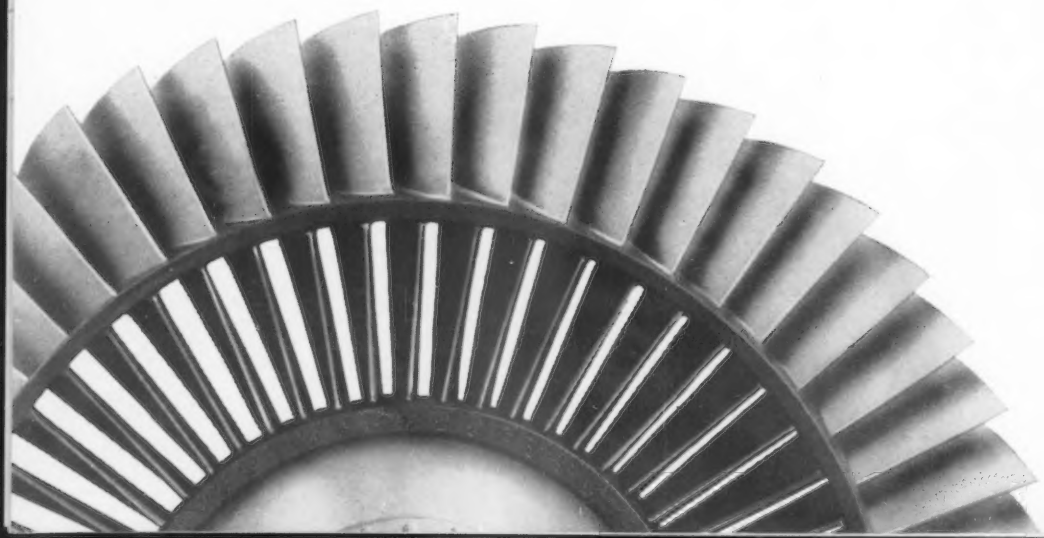

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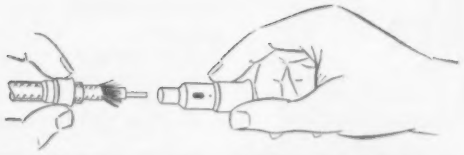

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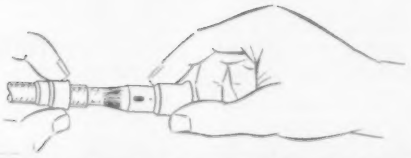

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APRIL 1959
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THE COVER STORY

The concept of the jet engine is having far-reaching socio-economic effects on our way of life. Geographic distances are now measured in terms of hours. The Convair 880 with its powerful CJ805 turbines will soon augment this new breed of jetliners. The shrinking of geographic distances may yet serve to bring the community of mankind closer not only physically but also ideologically.

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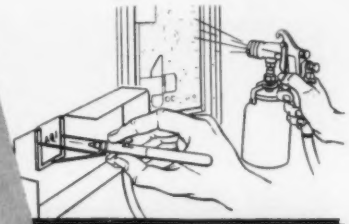

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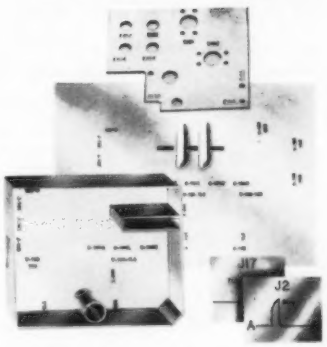

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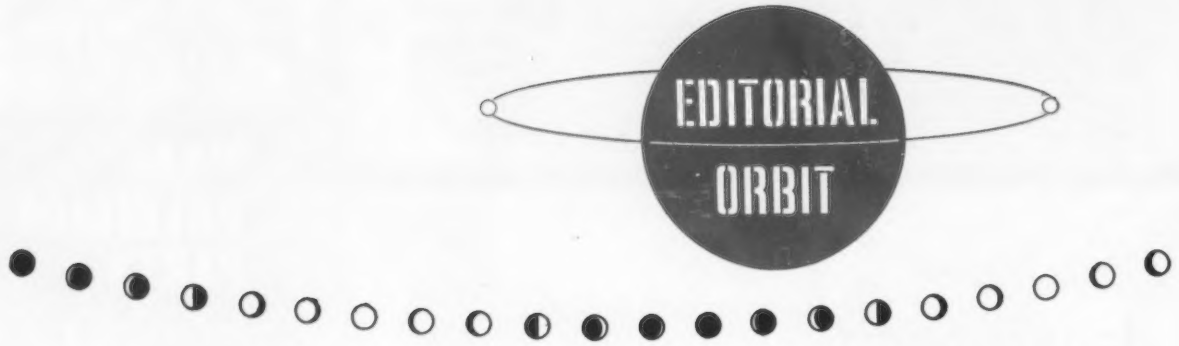


170 million critics

Everytime we turn around these days, someone is taking a pot shot at the Armed Forces. Seems as though when anyone has a fight to pick, they try someone who can't fight back.

Everyone's judgment is subject to question and this is the easiest thing in the world to do.

How many of us however, are willing to swap our jobs for a similar one in the military, to be governed not only by the articles of war, but by political whims and 170 million-odd taxpayers. It's not a happy situation.

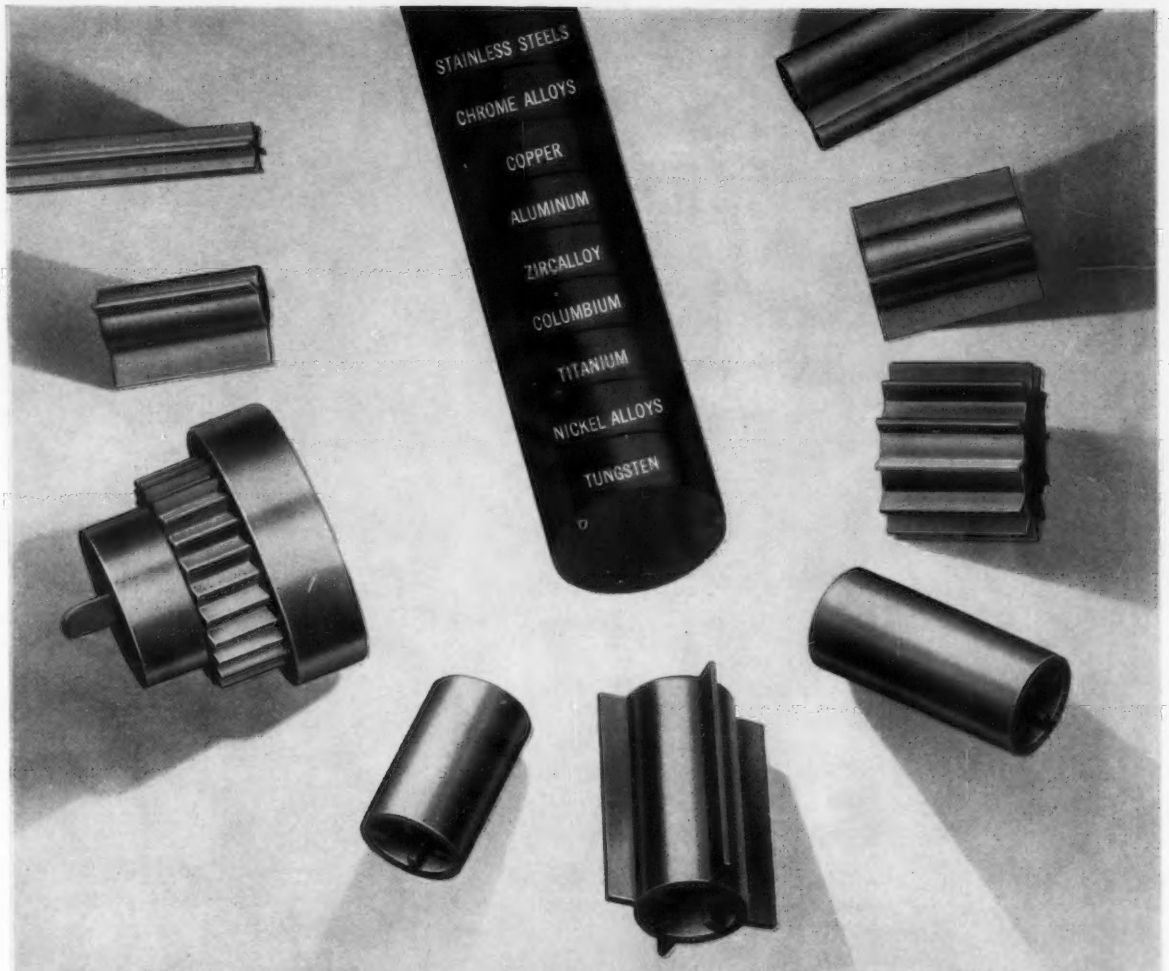
For the most part, both the civilian and military of DOD are doing their best to do a good job. From what we have observed they are hard-working sincere people. True, they probably make mistakes . . . so do others.

Before we become highly critical of the Army, Navy and Air Force, perhaps we should sit back, think and evaluate why decisions were made. After all, it is possible that the military will know a lot more about a given strategic situation or problem area than we do.

Another thing that people try to promote is the inter-service conflict. Did you ever think of how many joint projects are being worked on? Projects that require the cooperation of sometimes, the three branches of the services?

It might be worth while that instead of fighting the Armed Forces, we decided to cooperate a little bit. We might be pleasantly surprised.

Editor



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By DYNAPAK, a breakthrough in high-energy-rate metal working equipment

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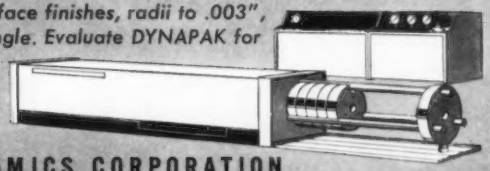

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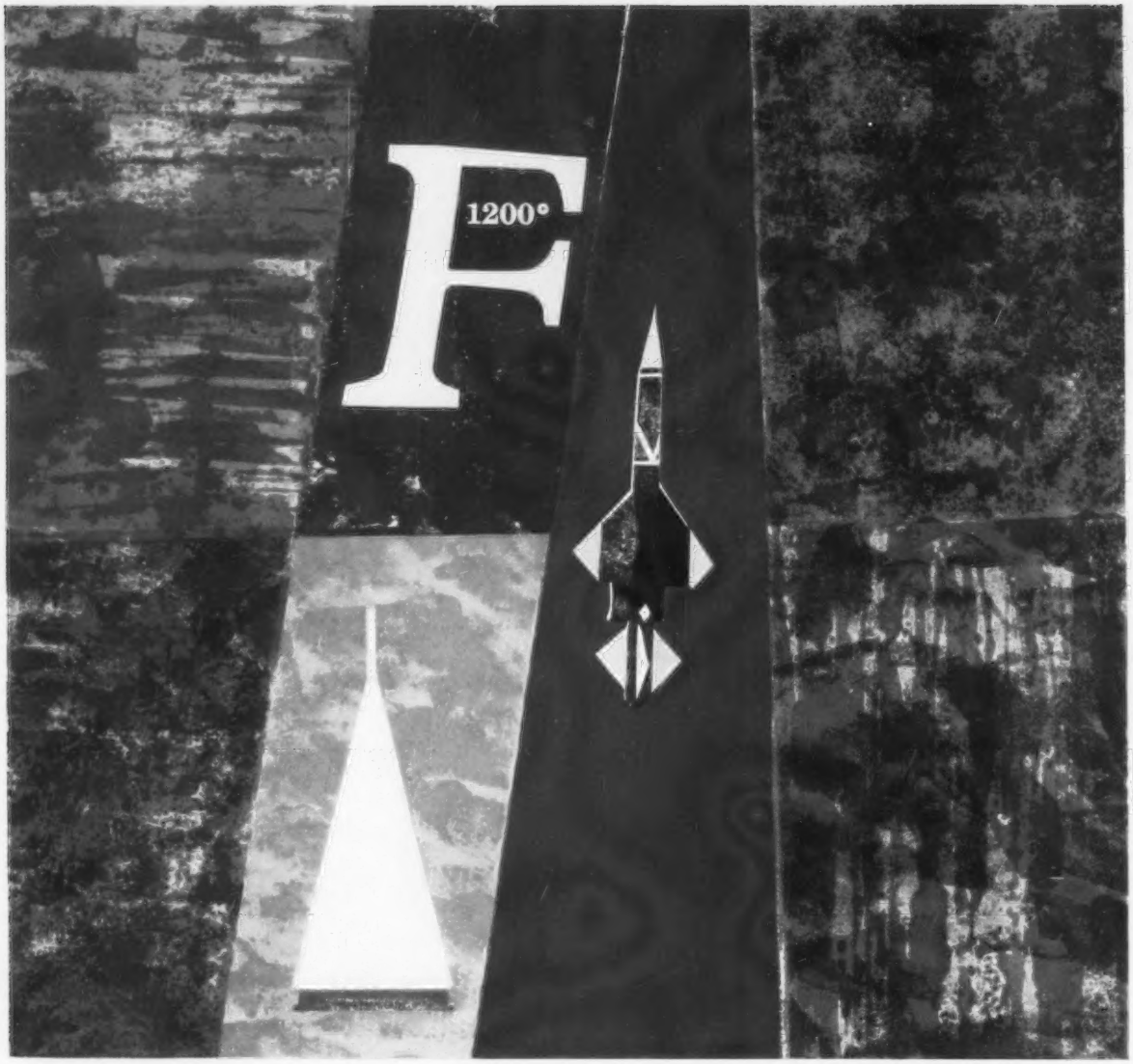

BRUNSWICK "SHOOTS" THE RADOME RANGE TO 1200° F

Brunswick makes a new breach in the thermal barrier with newly developed non-metallic materials that boost the temperature tolerance of radomes and nose cones to 1000-1200°F for limited exposure periods – almost twice the previous limit. This new advance in Brunswick's Strickland 'B' Process of filament winding opens a new chapter in aircraft and missile designing.

New "SBP" filament winding results in the highest strength-to-weight ratios ever obtained in radomes and nose cones with significant weight savings over conventional structures. With unmatched electrical uniformity, Brunswick builds them to meet the tightest tolerances for dielectric constants and compound configurations. Brunswick offers full electronic testing facilities.

Brunswick radomes and nose cones now slice skyward on such supersonic aircraft as the advanced Convair F-106; on such missiles as the Boeing Bomarc and Lockheed Q5. For details on Brunswick's leadership in research, development and testing, write: The Brunswick-Balke-Collender Company, Defense Products Division, 1700 Messler St., Muskegon, Mich.

BRUNSWICK

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Circle 7 on Inquiry Card, page 81

non-metallics for rocket components

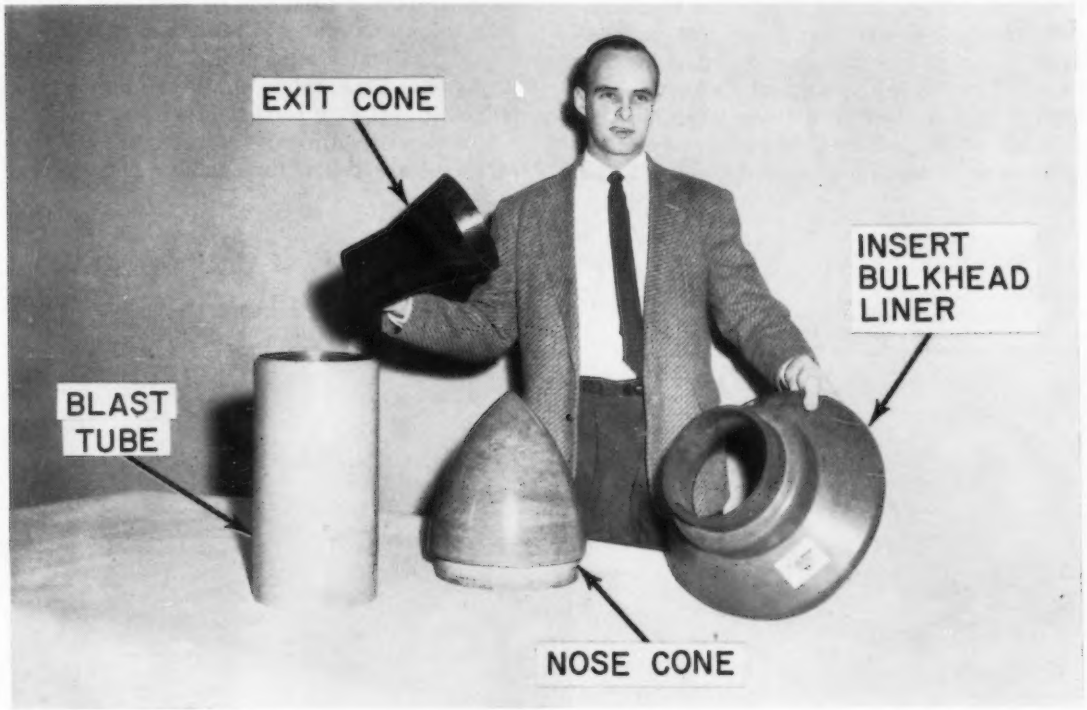
workable as putty, inorganic silicates with organic binders offer barriers against heat and corrosion

by S. Peter Kaprielyan

Man's ingenuity, having tapped new and more effective sources of energy, is presently challenged to cope with the attendant high temperatures.

In rocket propulsion a new generation of non-metallic insulation materials is being developed to block heat propagation. One breed of such materials has come about by combining inorganic silicates and organic binders. At combustion temperatures, reaction between the heat-resistant silicates and the binder produces a charred surface layer; heat reflectivity and resistance to erosion are the useful properties of this surface, hence of the parent material. Haveg Industries Inc., Wilmington, Del., is presently producing such materials; exotic names such as Rocketon, Missileon, Planeton, Mercuron, Asteron, Orbiton, and Galaxon denote these non-metallics

Typical components for rocket engines manufactured by Haveg process represent some current applications.



with diverse properties. Haveg's know-how with non-metallics is based on extensive experience in the manufacture of corrosion-resistant chemical tanks and related equipment. The processing and manufacturing methods of the above family are basically refinements on those used for the chemical industry.

Typical Properties of Haveg Rocketon

Compressive Strength, psi	15,000
Tensile Strength, psi	6,000
Ultimate Shear, psi	9,500
Tensile Modulus, psi	8.7×10^5
Compressive Modulus, psi	5.3×10^5
Shear Modulus, psi	0.8×10^5
Hardness (barcol #934)	49
Thermal Conductivity, BTU/ft²/°F/hr/ft of path	0.25
Thermal Coefficient of Expansion (in./in./°F)	1.3×10^{-5}
Density (lb/in.³)	0.061

	Range	
Insulation Resistance, megohms	6 to 10.3	6.2
Dielectric strength	0 to 67	8.0
Power Factor (60 cycles)	0.49 to over 0.50	0.4
Power Factor (10^6 cycles)	0.01 to over 0.50	0.14
Dielectric Constant (60 cycles)	5 to 20	7.5
Dielectric Constant (10^6 cycles)	3 to 6	5.9
Dielectric Loss Factor (60 cycles)	1 to 6.5	3.0
Dielectric Loss Factor (10^6 cycles)	-0.06 to 0.8	0.8
Arc Resistivity (seconds)	0 to 97	97

Workability Characteristics

Production-wise, a great advantage of these materials dwells in their extreme ease of workability. Upon mixing of resins and silicates, derived from refined grades of asbestos by chemical treatment, the consistency of the uncured material is that of wet clay or mixed dough. The mixture is firm enough to support its own weight as applied to a surface in a thick layer; in this stage it can be molded, cast, extruded, or applied by hand so as to assume a desired shape. Filler fibers may be oriented to achieve favorable sectional properties or erosion characteristics. Glass cloth or other fibrous fabrics may also be incorporated to obtain additional cross-sectional strength. Where needed, section thickness may be varied as required.

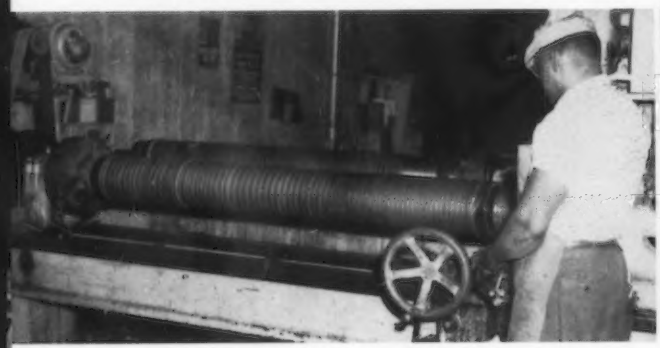
Manufacture of Tubular Shapes

The typical cylindrical configuration of current missiles lends itself readily to reproduction by spinning. The term "spinning" as used here describes the process by which the material is pressed into or on top of a rapidly rotating mandrel. Material is applied by rolling between the mandrel and a special roller. The action is the same as rolling pie-crust with a rolling pin. It is noteworthy that there are no size limitations, for final product, imposed by this method. This claim is borne out by the current production of 14-ft diam chemical tanks by this method.

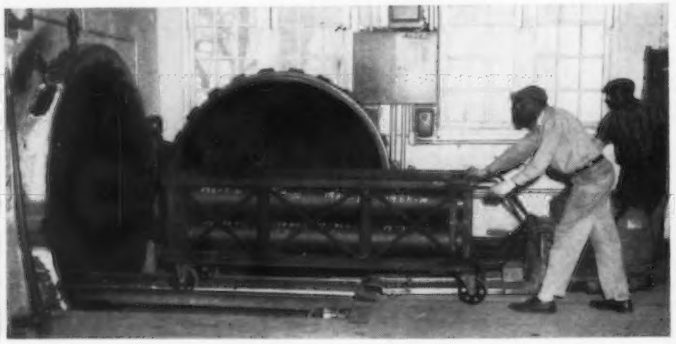
For diameters less than 6 in., production is accelerated by initially depositing the material through extrusion. In this instance mandrels are first passed through a circular die discharging the material under pressure. Since the material is deposited on a mandrel moving lengthwise, the fibers are oriented longitudinally; circumferential orientation is produced by a subsequent operation. Sections of Nike-Hercules and Lacrosse tubes are being produced by extrusion and spinning in approximately 12-in. diam stock.

The material used in these applications is Rocketon. Blast tubes for these missiles are extruded in 8-ft long sections, then are spun. Upon completion of spinning, the tubes are placed in a rack and are baked for curing. Next operation

Spinning of blast-tube lengths, after extrusion, orients fibers circumferentially. This improves hoop strength characteristics of the tubes.



After completion of spinning operation, blast tubes are supported in a mobile rack and conveyed into autoclave for curing.



involves the withdrawal of mandrels from within the cured blast-tube lengths.

The I.D. finish of the blast tube is imparted by the O.D. finish of the steel mandrel. For a typical blast tube, some 150 control stages may be used to check conformance with specifications. These stages begin with the initial processing of raw materials and extend through final inspection and packaging. Similar to metallurgical processing, test coupons from each batch of compound accompany the tubes through their curing cycle. Conventional machining technique, with carbide-tipped tools, is used for finishing the O.D. of tubes; diamond-tooth saws are used for slicing the finished sections of blast tubes to length. Threading, tapping, planing, milling, and grinding are processes likewise applicable to these materials.

Ring-like insert bulkheads or throat sections, for missiles, are produced by pressure molding between matching dies; pressure is supplied by the platen of a 2000-ton vertical hydraulic press. Parts with intricate shapes are produced by "transfilling." This is a process of confining the material in a steel mold, while curing, to insure contour conformance.

Joining and Filleting

Discontinuous structural features, joints, webs, pads, and imbedding of thermocouples is feasible by "indenting." This process consists of forcing the original state clay-like compound, under low pressure to the desired shape; after curing, the additional material or the joint displays the same properties as the parent material. Minor surface repair may be made by this process.

The materials and the methods used by Haveg are adaptable both to short-run and to quantity production. This is based on the ready workability of the compound and its delayed room-temperature curing characteristics.

Applications of Non-Metallics

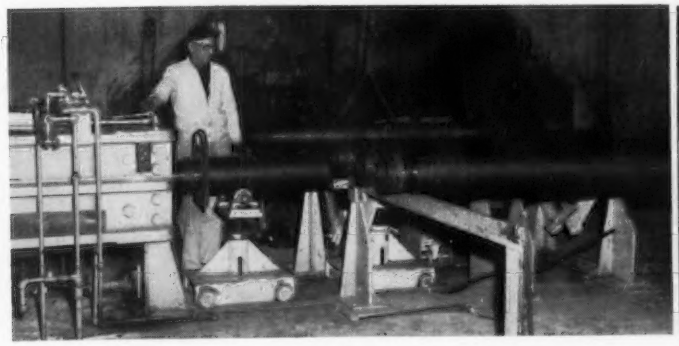
Current propulsion and reentry techniques are inseparable from attendant heat problems. For this reason, insulation materials will play an increasingly vital role in space exploration. Non-metallics are already in use with considerable success. Rocketon, has withstood about 6000°F for brief periods, and exposure to 3000°F for several minutes. Other members of this family have shown ability to withstand higher temperatures under operating conditions.

The following are some of the applications for non-metallic insulation materials:

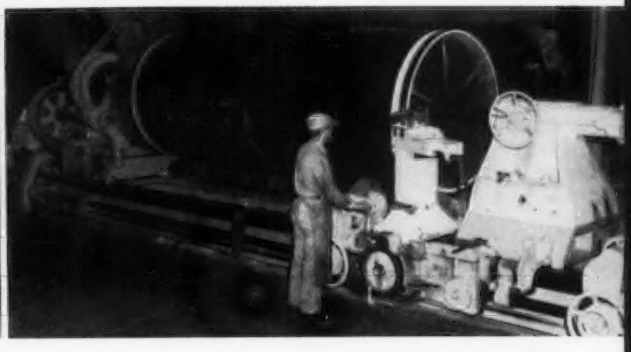
- Rocket blast tubes, nozzles, flame deflectors, and control vanes in direct contact with flame.
- Protective surfaces, enclosures, or encapsulation for electrical or other types of components.
- Protective surfaces for structural components for aircraft and missiles.
- Sandwich structures exposed to high temperatures.
- Control surfaces for high-speed drones, aircraft, and missiles.
- Large enclosures for biological specimens slated for reentry tests.

✦

Cured tube lengths are seen during pulling operation At this station steel mandrels are withdrawn from the blast tubes preparatory to machining.



Large diameter missile components can be produced economically, using basic process developed for industrial applications.



Douglas Skyhawk is used by US Navy for "low level" delivery of nuclear weapons. Delivery technique used has become known as the "idiot loop." Release is effected during upward phase of immelman turn.

A4D's "tadpole rudder"

Douglas reverts to adhesive bonding, stops skin cracks induced by sonic vibrations

Douglas A4D Skyhawk rudder section was originally designed and built as a conventional riveted structure. Pre-service load, and vibration tests made it soon apparent that this configuration was failure prone. Vibrations induced by sonic flight could cause cracks between rivets on the skin.

Production research showed that the rudder could be made failure free by using rivetless, bonded, aluminum cored structure.

The revised design has now proved itself in service. No skin-crack failures of the "tadpole rudders" have been reported. The descriptive phrase "tadpole rudder" is derived from the fact that a cross section of the complete rudder resembles a tadpole. The bonded rear section represents the tadpole's tail.

Manufacture

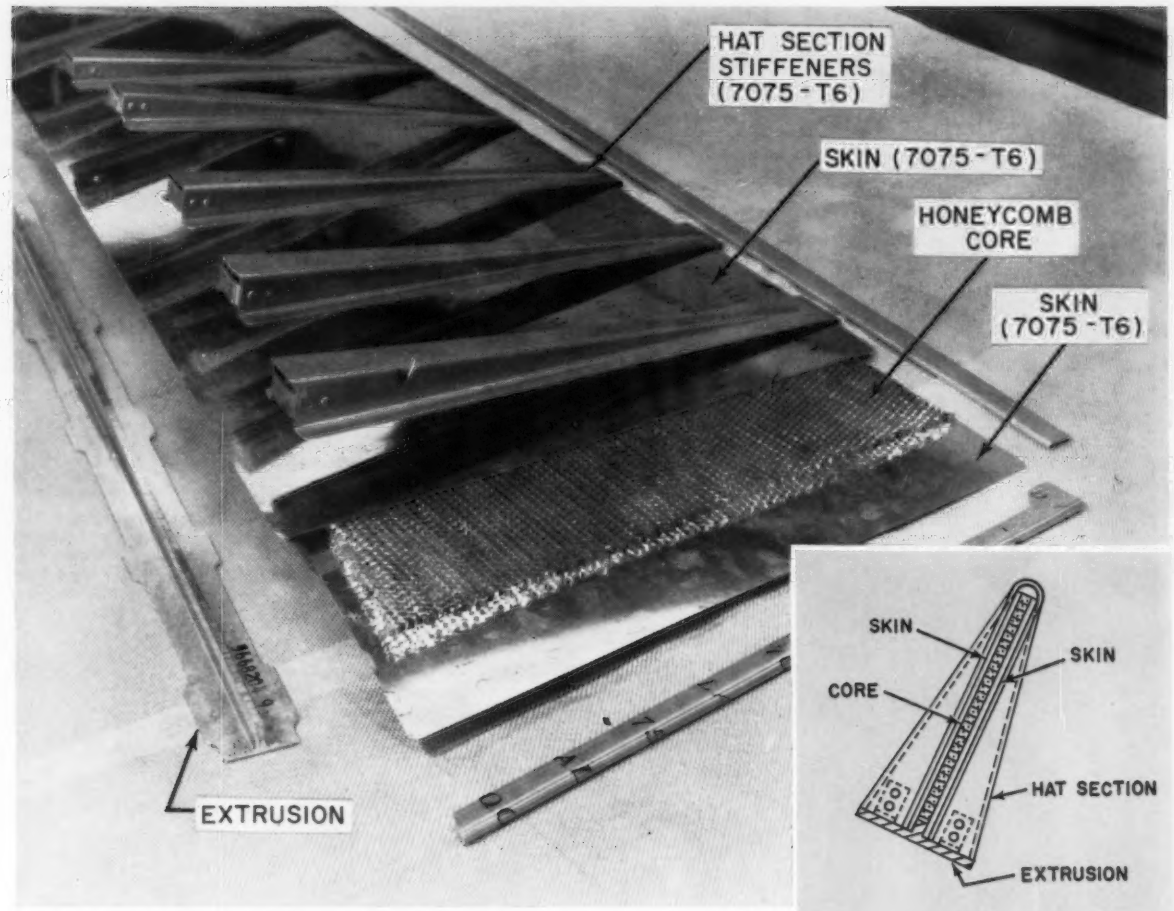
All components comprising the bonded rudder section are prefitted in a series of jigs before bonding is effected. Prefit insures that no assembly misfits arise in partially assembled rudders. Tailored parts are then chemically cleaned.

Narmtape 103-A coated with EC1595 adhesive is used in the honeycomb/skin assembly. The remaining metal-to-metal bonding is done with Narmco Metlbond Type I adhesive and Metlbond 4021, Type II tape.

Test coupons are bonded with each rudder for subsequent quality control testing.

Materials

Narmtape 103-A consists of an elastomeric, modified-phenolic film supported by a nylon fabric, and a liquid primer of about 10 per cent solids. Adhesive manufacturer Narmco Resins and Coatings, recommends cleaning of all parts to receive this adhesive with sodium-dichromate sulfuric-acid bath. Recommended procedure follows. Exact details of Douglas' operation were not revealed.



Exploded view shows trailing edge of "tadpole rudder" assembly on A4D. Adhesively bonded structure has replaced earlier riveted assembly.

All parts are prefit before cleaning and adhesive bonding. Outer skin is matched to core in fixture in this illustration.

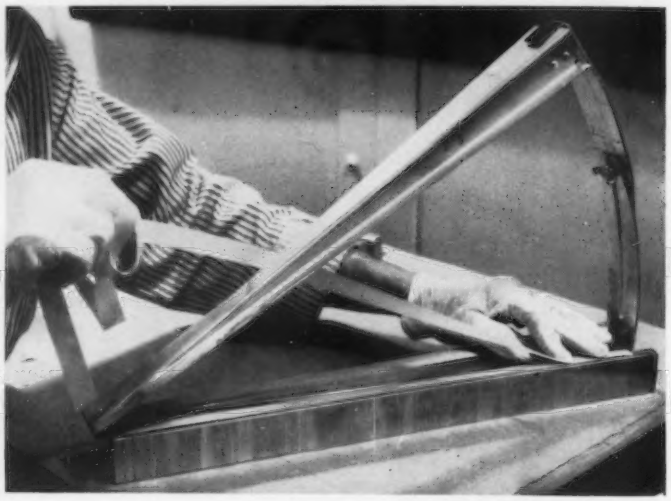
1. Clean parts with methyl-ethyl ketone.
2. Immerse 5 to 7 min in 140 to 160° F solution of:
   H_2O .....30 parts
   H_2SO_4 .....10 parts
   $Na_2Cr_2O_7$ ..... 4 parts
3. Rinse thoroughly and dry in hot oven.
4. Prime parts (faying surfaces) with about 0.005 in. thickness. Air dry 60 min, oven dry 15 min at 180° F.
5. Apply the phenolic film adhesive.

All parts should be handled with clean white gloves during and after the cleaning operation.

The EC-1595 adhesive used in company with Narmtape 103-A is a 100 per cent solid, epoxy paste, manufactured by the 3M Co. The adhesive is applied with a wide blade knife to a thickness of 2.5 to 5 mils. This adhesive is well suited to use with honeycomb because it has self-filleting properties. *continued on next page*

"tadpole rudder"...

continued



Personnel wear clean, white-cotton gloves while handling parts subsequent to cleaning. Here, Metlbond 4021 Type I tape is applied to hat section.

EC 1595 epoxy paste is used on skin/honeycomb panels. Test coupons are bonded with each production part.

Bonding is effected in three steps: skin-to-honeycomb and inner channel to hat section. These two assemblies are then bonded to each other, as shown.

The Metlbond 4021 adhesive system has been used successfully throughout the industry for some time. It is comprised of a Type I modified phenolic resin in unsupported tape, and a Type II, 10 per cent solids, liquid primer. Standard sulfuric-dichromate bath described above is adequate for cleaning aluminum parts. Primer can be applied by either dip, brush, or spray methods. Manufacturers recommended thickness is 0.0005 in. After 60 min controlled-atmosphere air-dry, and 30 min force dry at 250° F, the Type II tape is placed in position.

Curing

The rudder section is bonded in three distinct steps.

Honeycomb/skin sandwich assembly with forward attachment flange is bonded in an autoclave. This assembly uses the Narmtape 103-A and EC-1595 combination.

Inside of tapered hat section flanges are bonded in an oven.

Complete assembly is made, and hat sections are bonded to honeycomb/skin sandwich under vacuum in large oven.

✦

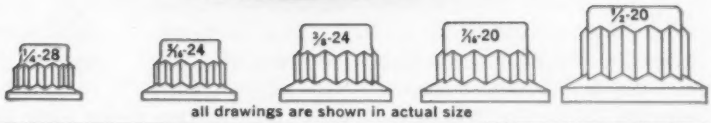
NEW *light-weight*

220,000 psi

ESNA SELF-LOCKING NUT*

for advanced
structural design...
high-tensile bolting

WEIGHT COMPARISON TABLE
in lbs. per 100 pieces



all drawings are shown in actual size

ESNA LH3393 (220,000 psi)	.44	.77	1.20	1.69	2.55
COMPETITIVE Lightest Nut (180,000 psi)	.60	1.00	1.50	2.15	2.82
COMPETITIVE Lightest Nut (220,000 psi)	.95	1.62	2.75	4.25	6.00

Tomorrow's hypersonic airframes must withstand flight stresses and related vibration conditions that would have seemed insurmountable even five years ago. Yet to achieve such speeds these aircraft will have to utilize lighter-weight structural components than their subsonic predecessors.

ESNA Type LH3393 double hex, external wrenching nut now offers the designer of tomorrow's airframes and missiles a structural fastener with the highest strength-to-weight ratio of any currently available self-locking nut.

Design refinements embodied in the LH3393 series consistently develop the full fatigue strength of 220,000 psi high strength bolts . . . yet these nuts are from 10% to 33% lighter, size for size, than even the lightest 180,000 psi locknut.

Additional weight savings are made possible by the smaller envelope dimensions of these new parts, since reduction of wrench clearance requirements permits reductions in the size of other structural components.

LH3393 series nuts are cold-formed from alloy steel, processed with the manufacturing skills and protected by the rigid quality control established during ESNA's 30 years of experience in supplying dependable aircraft quality fasteners. The same military approved, ELLIP-TITE locking device used on ESNA's complete line of NAS parts, assures reliable vibration proof self-locking performance at temperatures up to 550°F.

For specific dimensional, design and test data on ESNA's *new*, lightweight, 220,000 psi nut—Type LH3393, write to Dept. S23-43, Elastic Stop Nut Corporation of America, 2330 Vauxhall Road, Union, New Jersey.

ELASTIC STOP NUT CORPORATION OF AMERICA

*U.S. Patent No. 2,588,372

Circle 8 on Inquiry Card, page 81

"power package" for Electra

first all-American turbojet built around proven engine; prop designed to specific airframe and engine needs

by John P. Kushnerick

Lockheed Electra, first all-United States turbo-prop airliner, recently took to the airlanes under the power of an Allison "power package." In some quarters the aircraft represents a new concept. Inside the industry it represents another case of carefully engineering an airframe around a proven engine. Electra's 3750 hp, 501-D-13's are essentially the same T56-A-1 powerplant that has been in service with the Lockheed C130 for nearly three years. About 75 percent of the parts on the two powerplants are interchangeable; naturally some important engine ring changes have been made. The design, development, and production of this engine is a significant accomplishment worthy review.

Engine — General

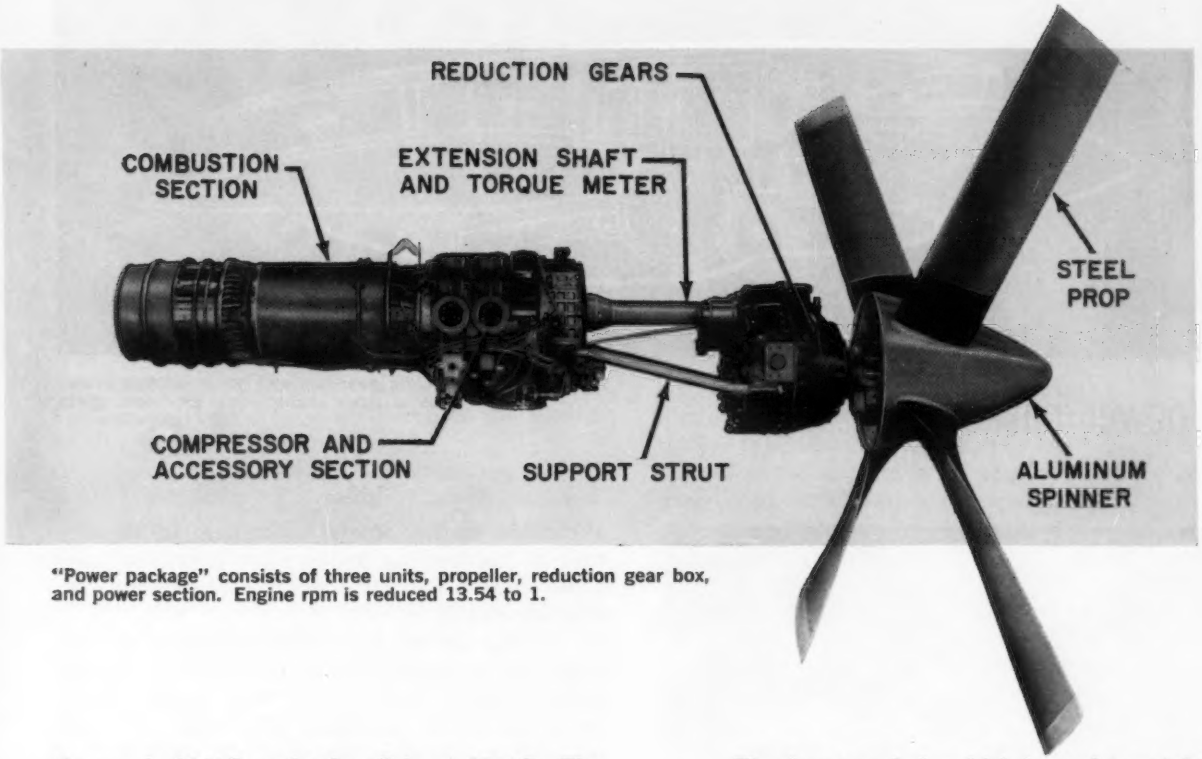
The engine consists of a reduction gear box and a power section. The gear box is secured to the power section by a torque-shaft housing and two struts.

The gear box is a magnesium casting. It contains two stages of reduction gears: a spur gear set, and a planetary system. Overall reduction is 13.54 to 1; this results in a prop speed of about 1020 rpm at the normal engine speed of 13,820 rpm. The reduction gear case also houses the propeller brake, the negative torque system and the auto-feathering system.

The power section consists of a 14-stage axial flow compressor, a can-annular combustion section, and a four-stage turbine unit, plus the various controls and accessories. The entire unit is alloy steel, or stainless steel except for the air intake housing and accessory drive housing which are magnesium alloy. Ram air enters through an S-shaped duct which has its inlet above the reduction gear box. Separating the gear box from the power section has the advantage of permitting large, unobstructed inlets. This results in high ram efficiency; important in as much as each per cent of ram recovery efficiency delivers an extra 40 hp.

Except for a ground and idle regime of 10,000 rpm, this engine operates at a nearly constant 13,820 rpm in flight. Powerplant rpm control is the responsibility of the propeller. Power control on a turboprop is so intimately interrelated between engine and propeller that the two should be considered as a single "power package."

Throttle manipulations result in a change of fuel flow which of course changes the amount of heat generated in the combustion chambers, and directly influences turbine inlet temperature (TIT). The TIT indication is the primary engine gage for the pilot after 100 per cent, or governed rpm, has been attained. Normal climb is at 895°C, and normal cruise is at 848°C. Max con-



"Power package" consists of three units, propeller, reduction gear box, and power section. Engine rpm is reduced 13.54 to 1.

tinuous is 932°C, and take-off is at 971°C. The propeller automatically selects the proper blade angle to absorb the power and maintain the constant 13,820 engine rpm.

Propeller

Propeller used on the Electra power package is a specially-engineered, Aeroproducts 13 ft-6 in., four-bladed steel unit, with an aluminum spinner. Electrical ice control is incorporated in the spinner; a small air inlet in the spinner is for oil cooling.

Propeller blades are hollow, and are made-up of a forged 4350 steel root-end and thrust member, with three integral stiffening ribs that run the length of the blade. A shaped, 4350 steel camber sheet is copper brazed over the ribs.

Open construction of the thrust member allows magnetic particle inspection of the main stress carrying unit before the airfoil skins are brazed in place. After brazing, each blade is slowly air hardened.

The blade is drawn in a solid faced fixture at 1050°F, with the blade root sealed with nitrogen (N_2). The gas pressure holds the sheet and cambered airfoil skins in the proper position during the tempering operation. Thus, they have the proper contour when drawn down from Rockwell C50 to C35.

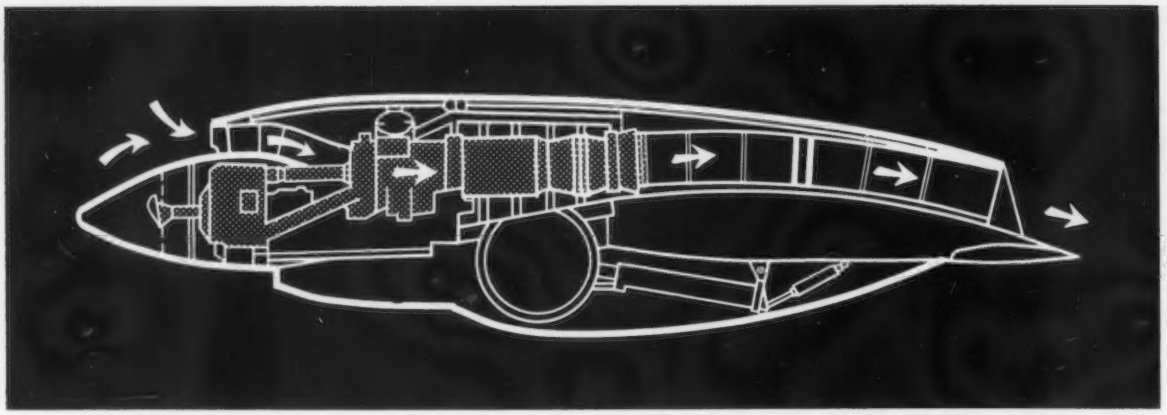
The four-way hub, which is used to retain the blades, is machined from an alloy-steel forging, shot peened for increased fatigue strength, and chrome plated to prevent corrosion.

Electrical power used in the auxiliary feathering system, ice control, and speed phase synchronizing is transmitted to the hub area through stationary brushes to rotating slip rings on the hub. Two brush blocks are used, one for the icing circuit, the other for prop control.

Propeller and corresponding engine overspeed are guarded against by: a mechanical pitch lock on the propeller, which prevents decreased pitch at 2 per cent overspeed; an overspeed governor on the fuel control unit, which is triggered at 4 per cent overspeed. Electrical feathering, and mechanical-emergency feathering are also provided if the two overspeed units do not perform correctly.

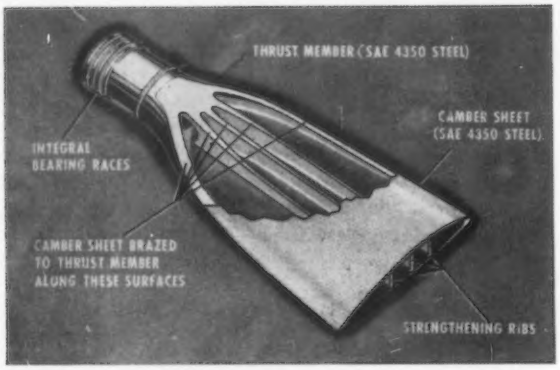
Engine — Design and Operation

Intake air enters the compressor where it is compressed 9.3 to 1, and delivered at approximately 32 lb/sec to the diffuser section. The compressor housing and stator assembly are forged in quarters and permanently bolted together into halves. The vane assemblies are bolted in channels in each half of the housing. Interstage leakage at the tips of the rotating blade rows is minimized by close running clearances. An



Separating gear box and power section allows use of large unobstructed air inlets, gives high ram efficiency.

"power package" . . . continued

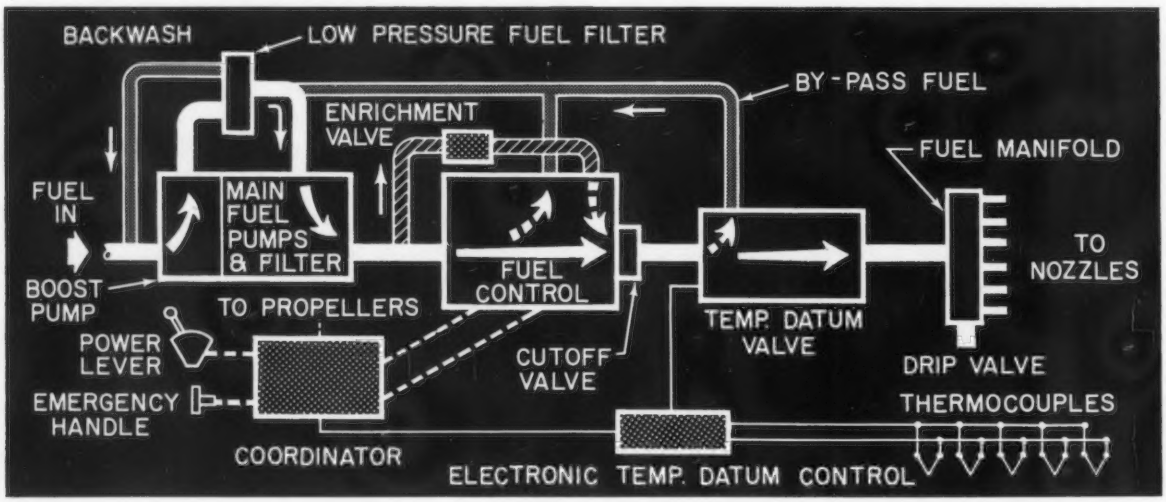

THRUST MEMBER (SAE 4350 STEEL)
CAMBER SHEET (SAE 4350 STEEL)
INTEGRAL BEARING RACES
CAMBER SHEET BRAZED TO THRUST MEMBER ALONG THESE SURFACES
STRENGTHENING RIBS

Propeller is essentially 4350 steel. Skins are brazed on three longitudinal ribs.

abradable coating in the cylindrical inside surface of the housing makes close tolerances possible. Each blade row actually cuts its own running clearance.

Leakage at the inside diameter of the vanes is minimized by soft aluminum sealing strips mounted on the vane inner bands. These are machined to essentially zero clearance with the spacers between the rotating wheels. The running clearances are established by a careful seal break-in schedule during first operation of a new engine. Once the running clearances are established, no special operating techniques are required. The vane half segments consist of inner and outer bands and essentially radial vanes

Schematic shows fuel flow commencing at "fuel in," at left. See text, last column opposite page, for details.



cut from strip stock, hot upset and brazed together.

The compressor rotor consists of two stiff end wheels and a single center tie bolt for axial clamping, with intermediate wheels, each with an integral spacer, splined together at their outside diameter. The rotor is supported on a roller bearing at the front and ball bearing at the rear. Stainless steel forged blades are held in dovetail slots in the wheel rims by pins.

Fuel is introduced to the compressed air in the combustion chamber. Six nozzles, located in the centers of the combustion chambers, serve as injectors. Only about 25 per cent of the air flow is used in combustion. The remainder flows into liners through slots and keeps the flame from impinging on the liner shell. Cooling is achieved in this way.

The entire combustion section consists of a one piece outer tube, an inner tube forming a low pressure oil sump area between the compressor and turbine, and the six combustion chambers. These chambers are supported at the compressor end by the fuel nozzles, and at the aft end by the turbine inlet vanes. Ignition plugs are located in two of the chambers, with inter-connecting tubes providing cross ignition. Three chrome-alumel thermocouples are located at the exit of each combustion chamber for measuring turbine inlet temperature (TIT).

Four-Stage Turbine

The turbine stator consists of a series of fabricated casings supporting the vane segments. All vanes are precision castings of a nickel base alloy developed especially for high temperature applications.

The turbine rotor consists of four wheels and three intermediate spacers splined on a central shaft and clamped together tightly at the hub. The blades are of the same alloy as the vanes except for the fourth stage blades which are forged. They are fitted in fir tree slots in the wheel rims. The intermediate spacers feature four rotating labyrinth knives to control interstage leakage.

The rotor is supported front and rear on roller bearings. The turbine is coupled to the compressor by a shaft splined at either end, and located axially by a central tie bolt. Thus, compressor and turbine thrust oppose each other, the net thrust being carried by the ball bearing at the rear of the compressor.

Lubrication

A kidney shaped accessory housing is mounted on the bottom of the inlet housing, and is driven by the rotor through bevel gears. The fuel and control system components essential to the operation of the engine are driven by a spur gear train in this housing.

The power unit lubrication system consists of a pressure pump driven by the accessory housing furnishing oil through internal and external passages and tubes to oil sprays at the main rotor bearings. Four engine driven scavenge pumps return the oil to the tank. These four pumps assure proper scavenging under all flight attitudes. Oil pressure is regulated by a valve which passes oil not required back to the pump inlet. A filter at the outlet of the pressure pump prevents contamination of the oil system.

The portions of the engine air inlet area which are subject to icing are anti-iced by hot air bled from the compressor discharge. These items include the torque meter housing, struts in the air inlet housing, and inlet guide vanes. The flow of anti-icing air is controlled by the pilot when icing conditions are suspected.

Fuel Control System

Fuel control system consists of the fuel pump, the fuel control, the temperature datum valve, and the coordinator. All are mounted on the accessory housing under the compressor case. Fuel from the tank enters the engine driven pump which discharges into the fuel control.

The fuel control is essentially a hydro-mechanical metering valve which receives its intelligence from three sources: the power lever position selected by the pilot and the inlet air temperature and pressure. With this information the fuel control meters 120 per cent of fuel needed for the existing set of conditions and sends it to the temperature datum valve.

The temperature datum valve is an automatic fuel trimming valve which by-passes that portion of the fuel which is not required by the engine. This is done by a motor actuated needle valve which receives its signal from the amplifier. The amplifier, in turn, compares signals from the 18 thermocouples sensing turbine inlet temperatures and a potentiometer in the coordinator which is positioned by movement of the power lever. Therefore, when the pilot moves the power lever, he is actually selecting a turbine inlet temperature; the temperature datum valve by-passes either more or less fuel as required to produce the desired temperature.

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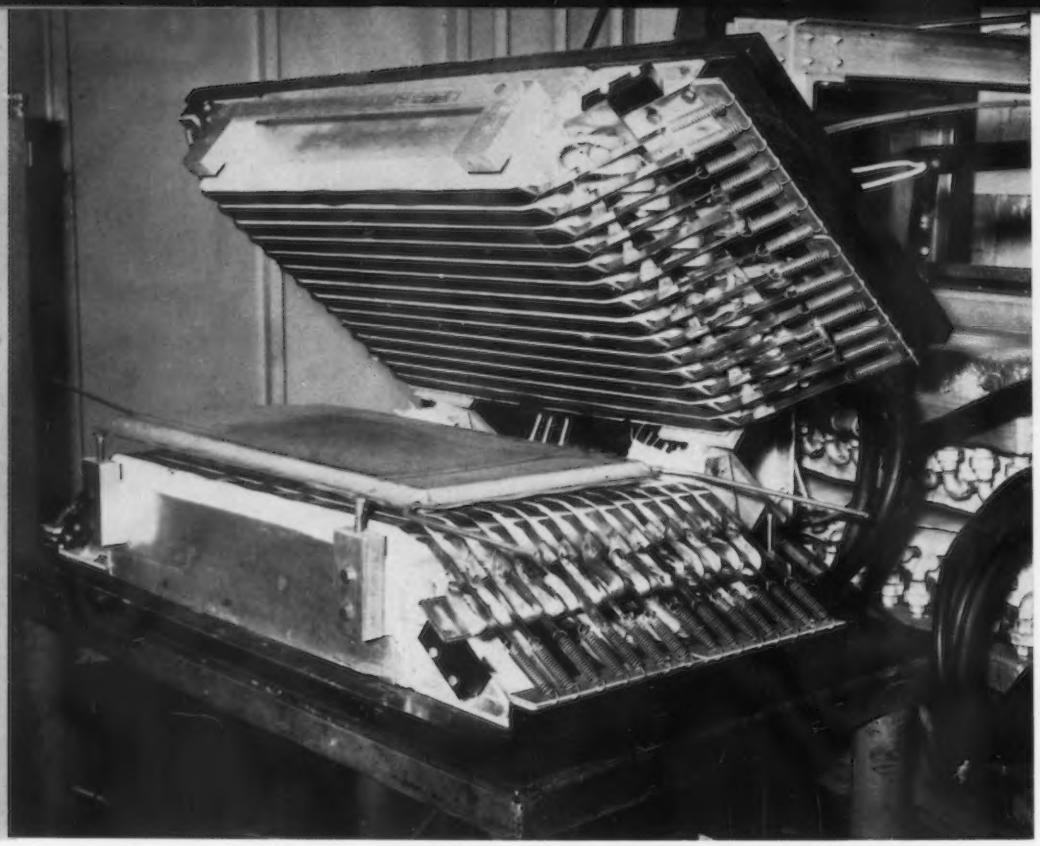


Electric blanket brazing fixture developed by Martin Co., shows assembled, and "bagged" panel in place. Springs hold Nichrome V heating strips in place. Leached-silica cloth is placed between "bag" and heating elements for electrical insulation.

electric-blanket brazing

a new approach to fabricating stainless-steel sandwich, portable equipment used

by Donald E. Wernz, supervisor manufacturing research and development, The Martin Co.

It is prerequisite of a production aircraft or missile system that the airframe be fabricated of abundantly available materials. It is equally important that these materials be formable and workable; that construction methods be economical; and that the resulting structure be light in weight, yet capable of withstanding natural and induced environmental stresses.

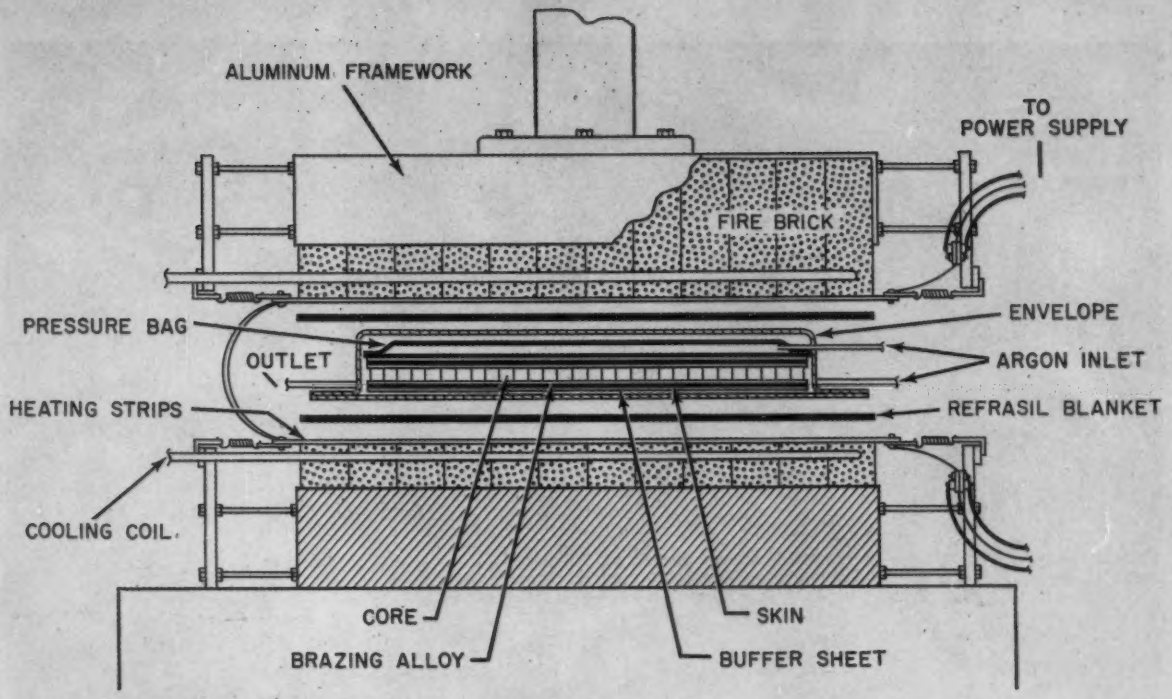
Initiative, necessity, and technological know-how have enabled the design of new aircraft and missile systems to advance far ahead of the supporting industrial base. Engine and fuel developments are creating power to go faster, farther, and higher, which results in a constant redefinition of operating environment.

Materials and Process Engineers can no longer wait for designs to materialize before establishing possible fabrication techniques. The design-to-hardware pace is too swift. To meet the prerequisites mentioned, "production" has been forced to anticipate "design." This has resulted in the growth and importance of production research.

The virtues of sandwich construction have been known for over a decade. The limitations of the conventional material of construction, aluminum, and the process of fabrication, adhesive bonding, have become apparent only more recently. The constant redefinition of operating environment has been responsible for the latter discovery. When environments exceed 330°F, both the material and the process are inadequate. This has resulted in a second generation of sandwich structure, brazed stainless-steel.

Electric Blanket Brazing

Present methods in fabricating this type structure are geared around the use of large fur-



ELECTRIC BLANKET BRAZING
schematic of fixture and panel assembly, layup

naces to produce the heat necessary in brazing. Recognizing certain limitations and extravagances in this approach, The Martin Co. devised what it calls "electric blanket brazing."

In this process, the brazing heat is supplied by a portable, electrical unit. Brazing can be accomplished on the plant floor in what is essentially a two piece fixture, i.e., a top and a bottom platen. The work piece is properly assembled, placed between the platens, and controlled current is passed through metal strips in each platen for the duration of the brazing cycle. Water can be circulated through coils in the platens to effect rapid changes in the temperature cycle if desired.

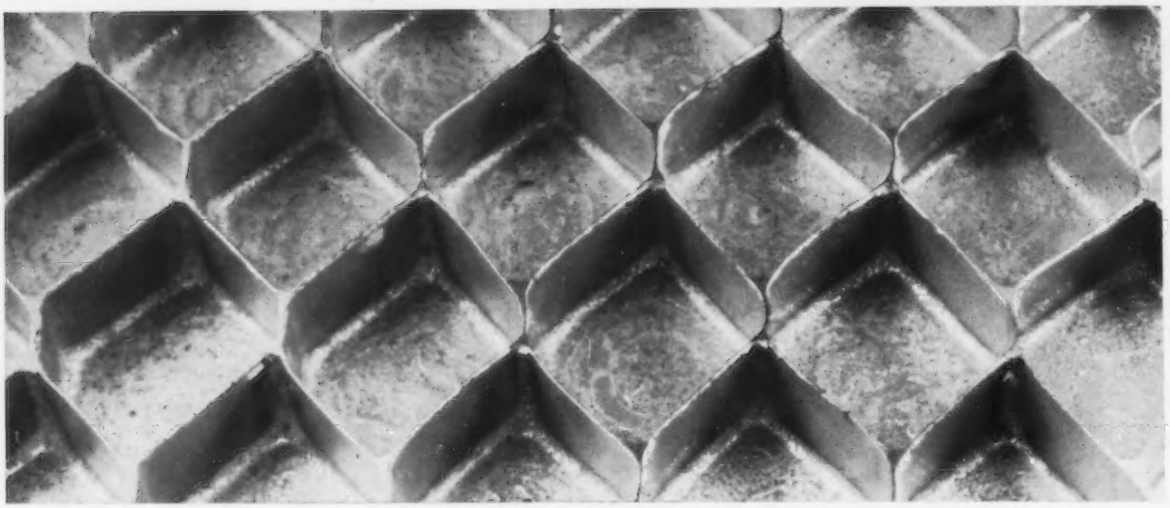
The more apparent advantages claimed for this process are:

- Decreased brazing time cycle, 13.5 hr vs. approx 34 hr.
- Decreased equipment costs; doubles as a heat-treating fixture, and uses a portable power supply that can be unplugged and moved from one fixture to another.
- Decreased fabrication costs, by elimination of specialized journeyman talents necessary with most furnace equipment.
- More favorable working conditions, since heating efficiency is about 65 per cent and thereby reduces excessive heat emission in working area. (Furnace efficiency is estimated at 10 per cent.)
- More efficient use of floor space, since blanket fixture is relatively small.

PORTABLE POWER SUPPLY

Development

The initial idea for this type of brazing, in lieu of the retort and furnace techniques, was evolved from studies conducted at Univ. of Colorado. Personnel there were doing simulated aerodynamic heating tests on a model wing with heavy pads. The pads brought a conduction heating blanket in firm contact with the specimen. Electric current passed through the heating strips



Brazed sandwich, with top skin removed, shows degree of "filleting" achieved in blanket process. Proper brazing alloy, thorough cleaning, and even heat are essential.

brazing . . . continued

caused heat to be conducted into specimen. The strips used were Kovar (nickel alloy developed by Stoupakoff Corp.). It was necessary to insulate them from the test piece with separate anodized sheets.

It was later learned that if zirconium heating strips were used, an insulating oxide (ZrO_2) film could be deposited on the strips by heating them in air. The insulating oxide was effective to test limits of 700°F. This meant zirconium strips could be laid directly against the piece to be heated.

With this basic information, Martin's Manufacturing Research and Development Section set out to construct and evaluate an electric-blanket brazing-fixture. The first attempts were marred by lack of a good dielectric between the heating strips and the work piece. ZrO_2 was no longer effective, since operating temperatures were now in the 2000°F area. Stainless steel and ceramic combinations were also ineffective. A suitable dielectric was finally found in Refrasil (a leached silica cloth, H. I. Thompson Products Co.). Almost simultaneously Nichrome V was found to be a more suitable heating element material.

Blanket Fixture Described

The electric blanket brazing fixture has evolved as a unit in which the heating elements, the cooling system, and the accessory tooling are all self contained. It is used for brazing and subsequent heat treating.

The fixture consists of an upper and lower blanket (platen) of Armstrong A-23 insulating fire brick on an aluminum framework. A network of steel water pipes is interplaced through the bricks so that the fixture can be cooled rapidly after an assembly is brazed.

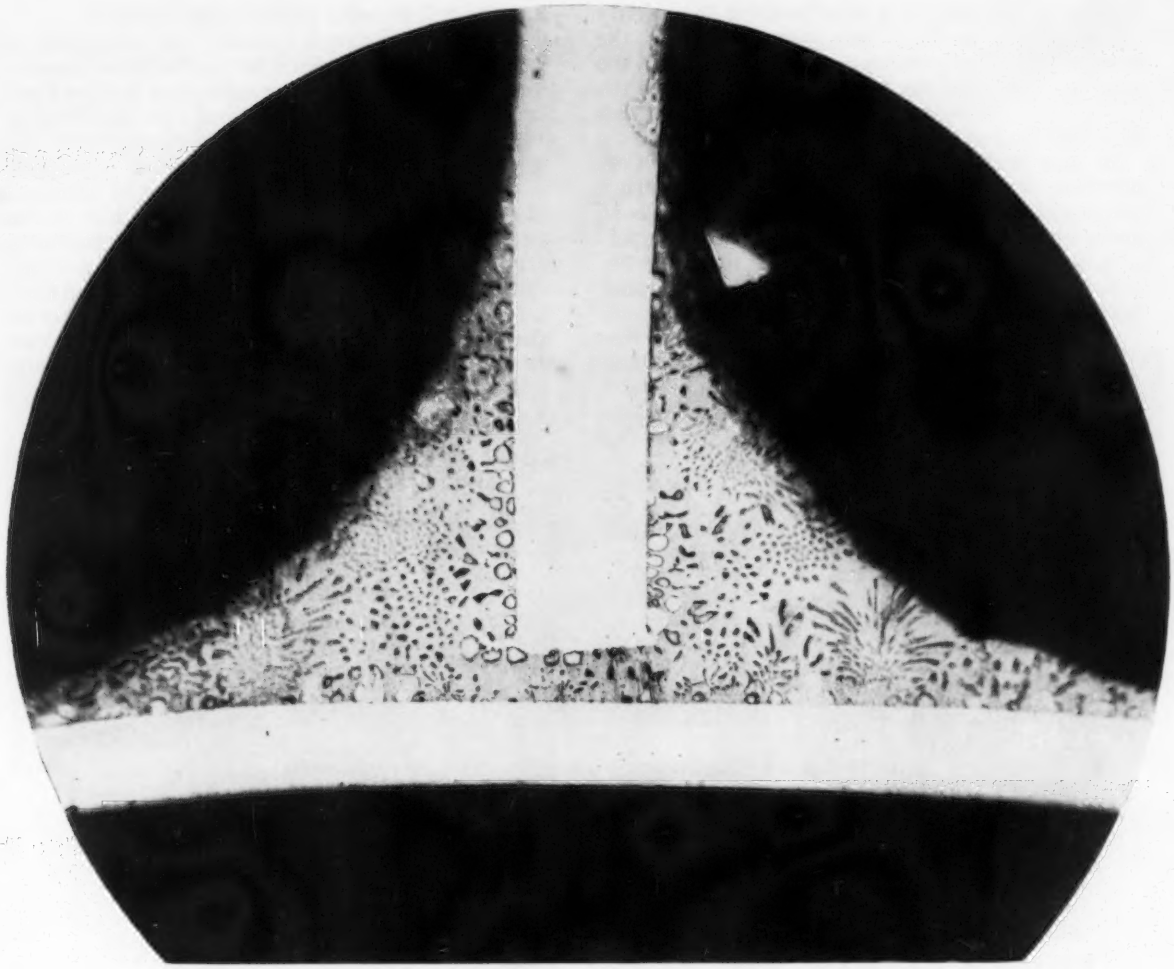
The Nichrome V heating elements are 1 x 0.010 in. strips, which run lengthwise across the face of the fire brick. The elements produce 14 watts/sq in. at 5 to 35 v. The voltage and temperature are regulated from a central control panel utilizing a 440 v, ac, 3-phase power supply.

Thermocouples embedded in the surface of the fixture and work piece indicate temperature within 25°F for the brazing cycle and within 10°F for the subsequent heat treating.

Panel Assembly

Properly cleaned stainless steel skins, core and brazing alloy are layed up in sandwich form. The brazing alloy (92.5 Ag, 7.0 Cu, 0.5 Li) is tack brazed to each steel skin. The assembled sandwich is placed in a 301 stainless steel bag, essentially two flat plates—the inner surface of each having been coated with a suitable parting agent. Steel tubes are inserted at each corner of the bag, and all edges are seam welded. Tubes are used for the removal of air and replacement with argon. Argon is circulated under pressure and provides an antioxidation environment throughout the entire brazing cycle. Pressure is provided by the dead weight of the top platen.

An alternative method of pressure application, still under development, is to use a stainless steel pressure bag inside the atmospheric envelope (see illustration). Argon is circulated into the pressure bag and thus provides a gaseous cushion between the top platen and the completed



Photomicrograph of skin-to-cell brazement verifies evenness and completeness of fillet. Martin uses brazing alloy of 92.5 Ag, 7.0 Cu, 0.5 Li percentage composition

assembly. This provides a more uniform application of platen pressure.

In either case, the outer steel envelope is separated from the Nichrome V heating elements by a layer of Refrasil, to prevent electrical short.

The assembled panel is then checked for oxygen content. A Cities Service "Heat Prover" is attached to the steel tubing when the unit indicates zero oxygen, and the brazing cycle is begun.

Brazing Cycle

As the first step in the combined brazing-heat treating cycle, the panel is set in the platen fixture. The platen temperature is brought to 1725°F and held for 15 to 20 min. Water is then circulated through the coils to cool the panel. Cooling rate is about 2200°F/hr. The steel envelope is removed from the brazing fixture, purging tubes are sealed, and the panel is refrigerated at −100°F for at least 8 hr. Time varies with the mass of the load.

After refrigeration, assembly is allowed to reach room temperature, purging tubes are reconnected, and the complete assembly is placed back in the electric blanket fixture. Argon is re-circulated through the atmospheric envelope, and temperature is brought back to 950°F for 1 hr. This completes the aging process and the assembly is then cooled under pressure to 100°F. The operation is accomplished in 13½ hr, as compared to about 34 hr for conventionally brazed panels.

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AIRCRAFT and MISSILES MANUFACTURING
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Failure of any part of a missile—be it the mighty Atlas, Jupiter or Thor—can mean failure of the mission. That's why the complex connections in the ducting systems of these and other missiles are silver brazed. These connections must stand up under 6,000 psi; they are tested to 12,000 psi.

In lines made to specifications by Flexonics Corporation, Maywood, Illinois, silver brazing joins a corrugated flexible pressure carrier, a braid sleeve and a coupling nipple—all of stainless steel; it permits joining all of these elements of the assembly without danger of annealing the pressure-carrying flex or the restraining braid as welding might do.

Assemblies designed for 6,000 psi operating pressure are required to withstand a 12,000 psi test and take four times their normal operating pressure before failure. They may also be required to pass a flame test in order to meet specifications.

The silver-brazed connections are used on hydraulic and pneumatic systems, fuel drain lines and vent tubes. Some of these applications involve rigorous service with extreme pressure shocks accompanied by sudden elevations of temperature, which may go from −60° to 400-600° F in a matter of seconds.

A more "high level" endorsement of Handy & Harman silver alloy brazing is not available. On the ground or in the air, the qualities of this remarkable metal joining method apply; strength, ease of production, cost, gas and liquid joint tightness to name a few. The entire brazing story is yours merely for the asking. Inquiries and metals-joining "problem exposure" may be addressed to Handy & Harman, 82 Fulton Street, New York 38, N. Y. We welcome the opportunity to work with you.

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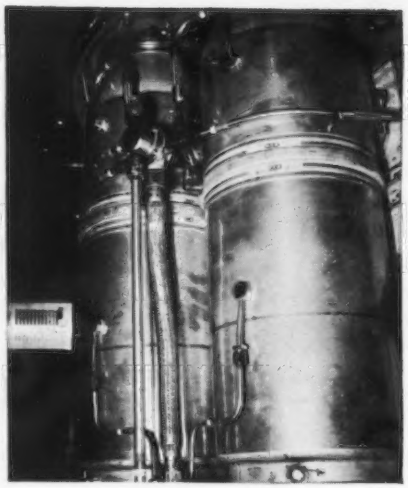
Assemblies in ATLAS Missile **HANDY & HARMAN** Silver Brazed

Intercontinental Atlas missile being made ready for launching.



Close-ups of missile section, showing silver alloy brazed ducting assembly.

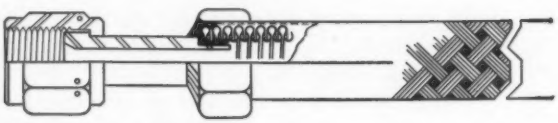


Diagram of pressure carrier.

FOR A GOOD START: BULLETIN 20.

This informative booklet gives a good picture of silver brazing and its benefits...includes details on alloys, heating methods, joint design and production techniques. Write for your copy.

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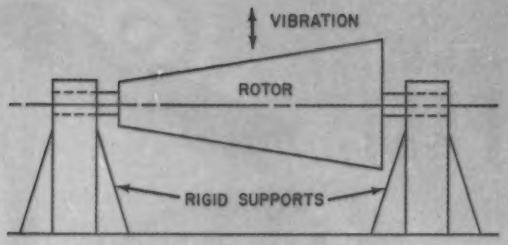
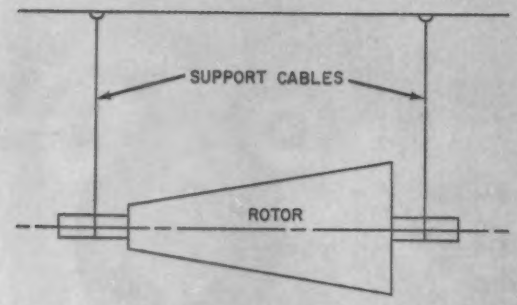


Vibration applied vertically (top) approximates closely a "fixed-fixed" condition; i.e., infinitely rigid supports at each end. Vibration applied horizontally, perpendicular to the rotor axis (below) approximates closely a "free-free" condition; i.e., infinitely flexible supports at each end.

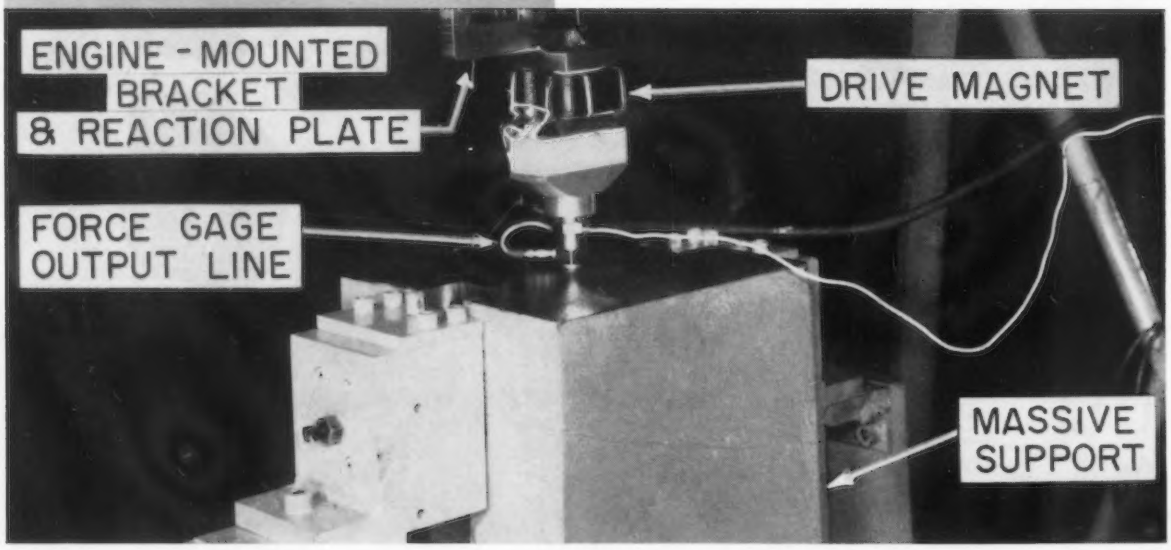


vibration testing jet engines

shaking gas turbines and components with small electromagnets offers versatility, accuracy, and economy

by **George E. Billman**, aircraft gas turbine dept., General Electric Co.

Typical drive magnet setup is shown for shake test.



The study of mechanical vibrations is an important aspect of many branches of engineering. In most applications it is of vital interest to know a system's resonant frequencies and its mode or modes of vibration. Designers strive to determine a system's or a component's criticals either above or below the frequency range of any exciting forces that may exist under operating conditions. However, the increasing complexity of a system makes it difficult to predict its vibration characteristics mathematically. Likewise, in a complex system it is almost impossible to predict dampening characteristics.

For aircraft gas turbines, it is most helpful to know vibration and dampening characteristics before the engines are tested. This information gives test personnel a very handy tool when vibration trouble occurs. That is, when known problem areas are reached, it can be determined whether it would be safe to increase the rpm or back off. In addition, test personnel would know in advance operational regimes where they should not dwell for long periods.

Laboratory methods of determining the criticals of an engine's motor components, i.e., compressor rotor and turbine rotor, have been tried; however, the results do not correlate with engine tests very well. Two methods are currently in use to determine the critical frequency of rotors. One is a "fixed-fixed" condition requiring infinitely rigid support at the bearing supports, and the other a "free-free" condition requiring an infinitely flexible suspension. The free-free condition is usually the more desirable since it involves only flexible cables at the rotor-bearing supports. These methods give results that are largely of academic interest since they yield only the component's criticals, and not the complete engine's criticals; the vibration modes and dampening characteristics of the engine, however, remain unknown.

Another approach is to bore a hole through the compressor and turbine casings, and with the engine mounted in the test cell to induce vibrations by a shake table. Monitoring the resultant vibrations will determine the resonant frequencies for a given operating range and the mode of vibration at these frequencies. However, this is both costly and time-consuming. Also, determination of dampening characteristics is difficult because the masses of the shake tables are mechanically connected to the prime mover, thus causing additional dampening.

A method which represents a significant improvement over previous test methods involves exciting the entire engine assembly with small electromagnets. Electromagnets capable of supplying an alternating force of less than 100 lb can be used for this purpose. Such electromagnets are sufficient to excite the resonant frequencies of present-day jet engines and larger ones of the near future.

Advantages

The system of exciting the resonant frequencies of a jet engine with small electromagnets offers the following advantages:

- Adaptability to testing of engines or individual components.
- Portability to any location, where a standard 115V AC power source is available.
- Accurate prediction of engine vibration characteristics.
- Reduction of time span of vibration tests.
- Overall Economy
  a. Initial system buildup (excluding support stands) for a four-magnet system with two amplifiers—about $5000.
  b. Labor and overhead costs for a test as described in this article (time span one week with three shifts)—about $5000.

Testing Equipment

The equipment used for shaking an engine with electromagnets involves the following:

A. Portable Drive System (Rack Mounted)
   1. 10 volt rms signal generator
   2. Electronic counter
   3. Oscilloscope
   4. Patch panel with phase shifting network
   5. Power amplifiers (260 watts each)
   6. 200 mfd. capacitor bank

B. Engine Shakers
   1. Electromagnets rated at 100-lb pull or less
   2. Adjustable magnet support stands (Mass over 500 lb)
   3. Steel brackets attached to the engine to provide a flat magnetic reaction path.

C. Vibration and Force Measuring Equipment
   1. Portable piezoelectric crystal type pick-up accelerometer
   2. Force gages with cathode follower and amplifier
   3. Band pass filter
   4. Oscilloscope
   5. Vacuum tube voltmeter.

System Setup and Operation

Let us consider a typical setup of the electromagnetic drive system for a jet engine containing four main bearings.

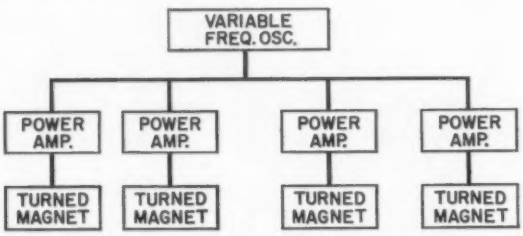
continued on next page

vibration testing . . . continued

In such a system, magnets are mounted on stationary support stands and the vibratory forces are induced into the engine. These stands are located along the horizontal and vertical engine centerlines so that the engine may be excited in either plane separately.

To supply a path for the magnetic lines of force, flat steel plates are mounted on engine flanges at or near main bearing planes. These plates are mounted so as to transfer the forces from the casings to struts, and then to the engine bearings.

To obtain a system with maximum flexibility, four magnets should be used, one for each main bearing; fewer magnets could be used but this would result in some sacrifice to system flexibility. The electrical circuits for the drive magnets consist primarily of a variable-frequency oscillator connected to a 260-watt power-amplifier; a schematic diagram of such a system is shown below.



The output of the signal generator branches into three separate signal inputs with adjustable "K" controls. These controls provide separate amplitude adjustments of two "in phase" signals and a third passing through a 90 deg phase-shifting network prior to reaching the power amplifiers.

The patch panel built into the system offers a selection for a multi-magnet drive configuration to operate either in phase (magnets pulling together), or out of phase (magnets alternating pulls). The 90 deg phase shift network is deemed necessary for alternating the pulls of the shakers. To obtain this alternating "pull" signal, the signals from two magnets are monitored on the oscilloscope, and the phase shifting network adjusted until a circular pattern is obtained. Usually, it will be unnecessary to operate the magnets out of phase; however, should it prove difficult to excite certain modes, this type of operation may be a valuable tool.

The engine vibrations are monitored through a calibrated piezoelectric crystal type pickup (accelerometer). This pickup is held by hand on specific engine locations; the received signal is fed into a monitoring oscilloscope where the relative amplitudes and phase relationships are read and recorded. Frequency is recorded as double the output frequency of the oscillator (each cycle means two excitations at the magnet). A reference voltage is recorded at a particular amplitude so that the relative amplitudes may be converted to absolute values of acceleration or displacement. To prevent physical contact between the reaction plates and the drive magnets, a space of approximately 1/16 in. should be initially set between magnets and plates.

The exciting force applied by the magnets is measured by a force gage connected between the magnet and the support stand. The generated force signal is indicated on a vacuum tube voltmeter.

Test Procedure

A typical test procedure for a jet engine with four main bearings is outlined below. This is a basic procedure for obtaining the required vibration characteristics in a minimum of time.

1. Supply power to the magnet or magnets for the particular test phase.

2. Vary oscillator frequency slowly over a predetermined range (say 20-120 cps).

NOTE: Monitor vibrations in the vicinity of the driven magnet and note all critical frequencies. Critical frequencies may be identified by a peak amplitude accompanied with a phase shift.

3. Investigate each critical frequency as follows:

a. Adjust oscillator to a critical engine frequency.

b. Monitor sufficient engine areas with the portable pickup to determine the mode shape. Also, monitor support systems and engine accessories.

4. Repeat the above procedure with the following magnets driving the engine:

a. 1-V only
b. 2-V only
c. 1-V & 2-V in phase
d. 1-V & 2-V out of phase
e. 3-V only
f. 4-V only
g. 3-V & 4-V in phase
h. 3-V & 4-V out of phase
i. Repeat (a) through (h) for the horizontal plane

Magnet locations are coded as follows:

No. 1 Bearing Plane—Compressor Front Frame—1

No. 2 Bearing Plane—Compressor Rear Frame—2

No. 3 Bearing Plane — Turbine Front Frame—3

No. 4 Bearing Plane — Turbine Rear Frame—4

-V or -H after the number denotes the vertical or horizontal plane of vibration.

5. Record the decay rate of the compressor and turbine vibrations at the fundamental resonant frequency.

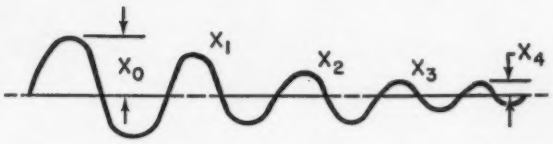
NOTE: The sinusoidal vibration of the oscillator output and the vibration of the engine are recorded on tape equipment (i.e., Brush Electronic recorders). Disconnect power to the magnet and record decay of the power and the engine vibration at a chart speed sufficient to read the sine waves recorded.

Analysis of Results

In analyzing the results of an engine shake test, the relative amplitudes recorded during the test are first converted to milivolts, or volts as the case may be, by means of simple ratio. For example, suppose we record 100 mv at our reference amplitude which was at a relative amplitude of say 20 units.

Let: X = any other relative amplitude

Then: $\frac{X}{20}$ 0.100 mv = milivolts at amplitude "X"



To convert these voltage values to acceleration a calibration curve for the pickup similar to the accompanying curve is used. The following formula is used to convert acceleration to displacement:

$$D - \frac{2a^{*}g}{(2\pi f)^2}$$

where:

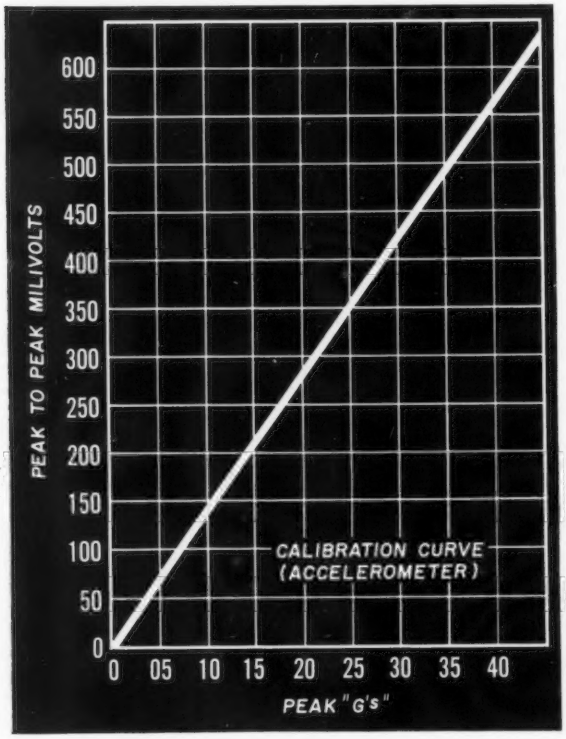
g = 386 in/sec²

a* = acceleration, (in g's) (from curve)

f = frequency, cps

D = Displacement (Double Amplitude), in.

Calibration curve is used for converting voltage values into acceleration.



The data are then plotted as displacement vs. engine location to show the mode of vibration for each resonance. Simple comparison will then show the most dangerous criticals.

The following formulas may be used in the analysis of the decay of the critical vibrations:

$$\text{Logarithmic decrement (Decay Rate)} = \delta = \frac{1}{N}\log_e \frac{Xo}{Xn}$$

$$\text{Amplification factor} = Q = \frac{\pi}{\delta}\sqrt{1 + \left(\frac{\delta}{2\pi}\right)^2} \approx \frac{\pi}{\delta}$$

NOTE: This is a representative amplification factor based on a one degree of freedom system. The vibration waves being analyzed must be taken from the portion of the chart after the power has decayed, to eliminate this variable in the analysis.

✦

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MODEL NO.	MAX. INLET PSI	MAX. OUTLET PSI	FEATURES	MAX. FLOW SCFM
GD10	3,600	500	Single adjustment regulator control	250
GD30	2,500	2,500	Load & bleed valve control	400
GD31	3,600	3,600	Load & bleed valve control	600
GD61C	2,500	2,500	Load & bleed valve control	170
GD62C	3,600	3,600	Load & bleed valve control	200
GD65	6,000	6,000	Load & bleed valve control	250
GD65C	7,000	7,000	Load & bleed valve control	250
GD80A	5,000	5,000	Load & bleed valve control	500
GD81A	10,000	10,000	Load & bleed valve control	800
GD86R	10,000	10,000	For remote control only	1,200
GD100R	6,000	6,000	For remote control only	20,000
GD100	6,000	6,000	Load & bleed valve control	20,000
GD200	6,000	6,000	Load & bleed valve control	50,000
GD700	7,000	7,000	Single adjustment regulator control; self relieving	250
SR10	3,600	1,000	Small, spring loaded regulator	4
LR20B	7,000	7,000	Spring loaded regulator; self relieving	2
LR20BSS	10,000	10,000	Spring loaded; stainless steel	2
LV10	7,000	7,000	Loader valve control	15
BPR10	7,000	7,000	Back pressure regulator	2

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Gulfstream readied

tool-up for executive transport completed, CAA certification expected this spring

Designed as an executive transport, Grumman's sleek Gulfstream made its public debut last fall. If all goes well, CAA certification will be complete in the spring of 1959 and deliveries will be made through distributors shortly thereafter.

The "fail-safe" philosophy has been used throughout the Gulfstream. That is, the structure incorporates redundant stressing, so that if one member fails completely, some other combination of members can carry the load completely. Hence the member has "failed-safe."

Gulfstream uses integral tankage in the wings to contain 10,000 lb of fuel for its two Rolls-Royce Dart engines (RDa 7/2). This power and fuel load give the 12-passenger aircraft a 2200 mi capability at 370 mph, with reserve fuel to meet CAR regulations.

Ground operation is independent of most support equipment. The stairway is self contained. Engines do not require external power for start. Auxiliary power unit allows ground operation of air conditioner, lights, radio, etc., while the engines are shut-down.

Tool-up is now completed for production models. Two prototypes, and the first production model have been completed.

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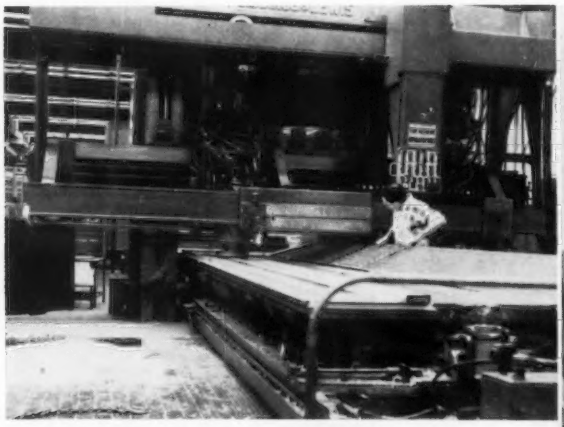
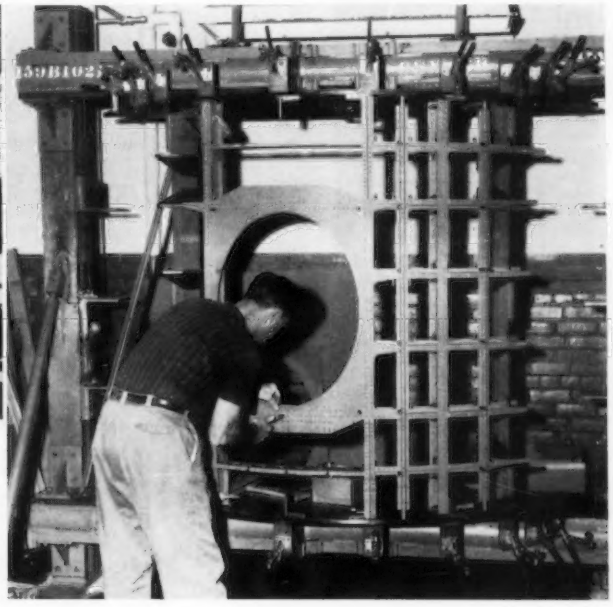
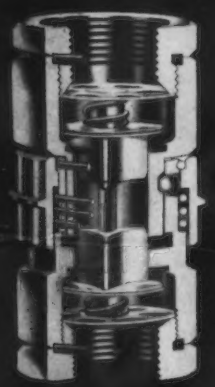


Integrally stiffened skins for Gulfstream's wing panels are milled on Giddings and Lewis machine.



Center fuselage section shown is constructed around two contoured bulkheads at the top and bottom of the tool.

← Circle 13 on Inquiry Card, page 81



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Convair 880

why and how Convair tooled its first jetliner for production from the outset; details of manufacturing sequences

by **R. W. Peters,** chief tool engineer, Convair-San Diego

Powered by four General Electric CJ 805-3's, Convair 880 is expected to cruise at 615 mph (TAS). Max cruise altitude is 40,000 ft

Determination to tool the Convair 880 from its inception with production tooling was based on the economics inherent in such a plan. To accomplish this program, it was realized that master gages would have to be fabricated before the first-ship production tools. The necessity of optical tooling to reduce tool manufacturing man hours per fixture was also realized. Consideration was given to "versionitis" by allowing compensation in each assembly fixture's basic structure for the foreseeable, or most likely, areas of change. This all meant, that to realize the economics of tooling for production models, rather than for prototypes, design engineers, production engineers, and procurement personnel had to share in the planning from the outset. This was done.

New Equipment

At the pre-engineering design stage, tooling engineers were already aware that new types of equipment would be required for fabrication of the detail parts on 880. Recommendations were made to the procurement department.

One of the larger pieces of equipment procured was a 105-ft, two-carriage, electro-hydraulic spar mill. The reason for specifying "electro-hydraulic" was to obtain a smoother finish at a fast feed rate. Another piece of equipment purchased was a 75-ton, 12-ft diam, Cyril Bath Radial Draw Former, equipped with elongation control. The parts now fabricated on this machine are "I" beams used in fuselage bulkheads, and "T" rails used in the wings.

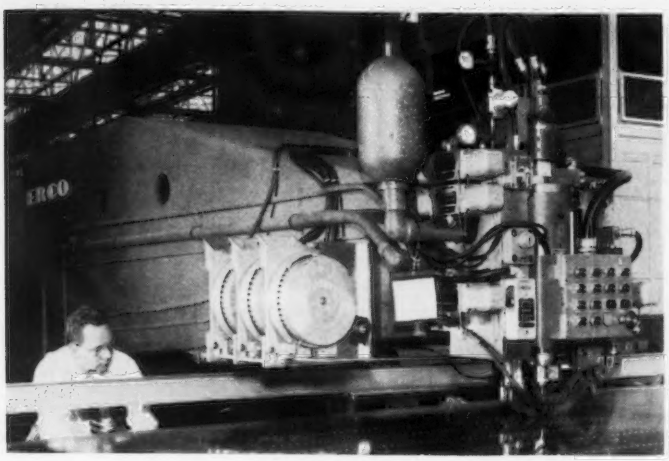
Wing Details and Tooling

Wings consist of front, center, and rear spars, with web stiffeners and truss-type bulkheads forming an integral box structure. An auxiliary spar, for support of the main landing gear, is joined to the wing box structure and fuselage for optimum load distribution. Scotch-weld adhesive bonding is used in combination with rivets for the integral fuel tanks. This method of joining is an outgrowth of the F-102 and F-106 Delta Fighter series.

The "tooling policy" in regard to major wing assemblies is: if the assemblies are "coordinated" to their mating assemblies, larger components will be "coordinated" to their mated components.

The desired relationship of the front spar to the center and rear spars is controlled by spar attach tooling holes. These are precision drilled in the wing bulkheads at the bulkhead table level. Bulkheads are coordinated to their attach angles on the spars through the use of common tooling plates.

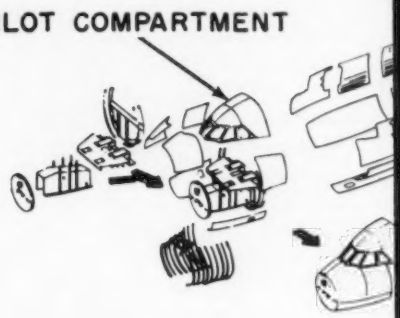
Truss type bulkheads, for right and left wing, are fabricated on a common base. Bulk-



Erco Automatic Riveter, drills, selects correct rivet length, drives rivet, and flushes rivet-head to skin with horizontal broach.

MANUFACTURING

3.5 day cycle t



⑥ FORWARD FUSELAG
PRIMARY

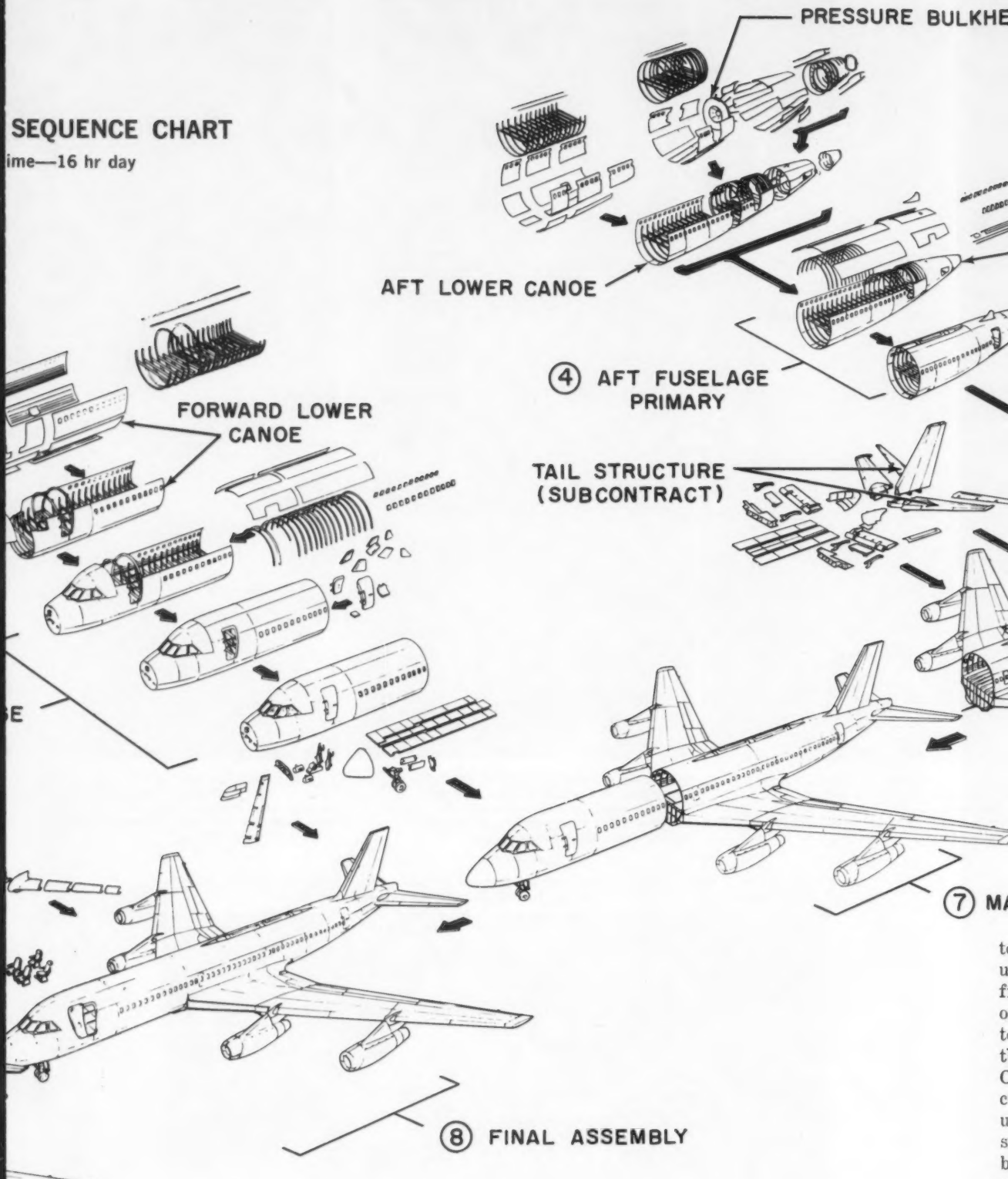
head fixtures are positioned 45 deg to the vertical support.

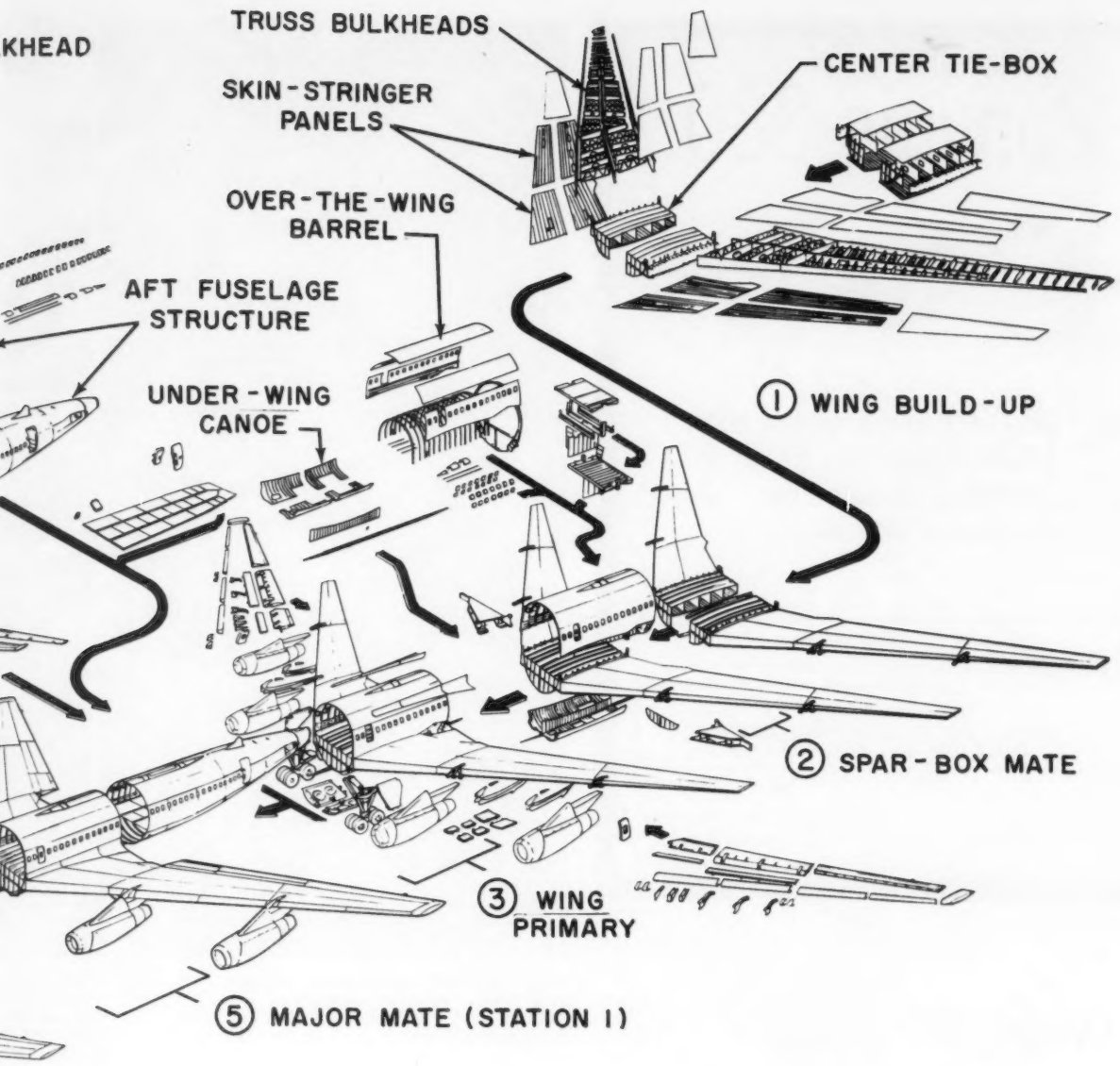
The surge and gas-tight bulkheads are fabricated on table-top fixtures coordinated to the spars through the use of facility gages. A unique feature of the wing bulkhead assemblies is that the fore and aft portion are assembled in a single fixture which has a split to compensate for the center spar. Coordinating problems are thus held to a minimum by assuring proper spacing of the erector set holes in the wing bulkheads.

Wing spars are first assembled in horizontal spar tables. The spar break at station 224 is not spliced until the next assembly sequence. This precludes troubles which may arise from spar growth in the riveting process. The spars are drilled with power fed tools, and disassembled for deburring and chemical cleaning. Scotchweld tape is applied. The spar is reassembled and final riveting is effected. The next sequence in spar fabrication occurs in the vertical spar fixture. The spar segments are positioned in the fixture by tooling holes in the chordline plane. The major operations accomplished in this fixture are: the drilling and riveting of the spar slice at station 224, drilling of the bulkhead attach holes, and boring and reaming of pylon attach fittings on the front spar.

Skin and stringer panel assemblies are preassembled with tack rivets. The skins are held

⑨ FACTORY COMPLETE


SEQUENCE CHART
ime—16 hr day
PRESSURE BULKHE
AFT LOWER CANOE
④ AFT FUSELAGE PRIMARY
FORWARD LOWER CANOE
TAIL STRUCTURE (SUBCONTRACT)
⑦ MA
⑧ FINAL ASSEMBLY



MAJOR MATE (STATION 2)

to contour with fire hose type clamping which utilizes the factory air lines. Before removal from the fixture, contour control bars are placed on each skin and stringer panel to maintain contour smoothness while the panels are awaiting their sequence on the Erco automatic riveters. Controlled from a Convair-developed electronic console, the automatic riveting machines have the unique feature of shaving the rivet to a contour smoothness of 0.00015 in. by using a horizontal broach. Upon completion of the Erco automatic riveting operation, the contour control bars are placed on the skin and stringer panels before they proceed to the clean-up station and into the wing buck.

Sweep back and dihedral of the wing are controlled through the center tie box assembly. The tie box is completely assembled in a vertical type fixture before being placed in the wing buck.

In loading the wing buck, the front spar is first placed in position. The center tie box, having been previously assembled to the end plate of the buck, is rotated into position; this determines wing Station O. The wing bulkheads, between the front and center spar, are then attached through the erector set holes at the front spar. The intermediate spar is placed in position using the erector set holes on the aft face of the forward bulkhead section. The aft bulkhead sections are then attached to the intermediate spar

continued on over-leaf

Convair 880

◀ extend fold-out to the right
article begins on page 33.
cut along dotted line
to remove and file.

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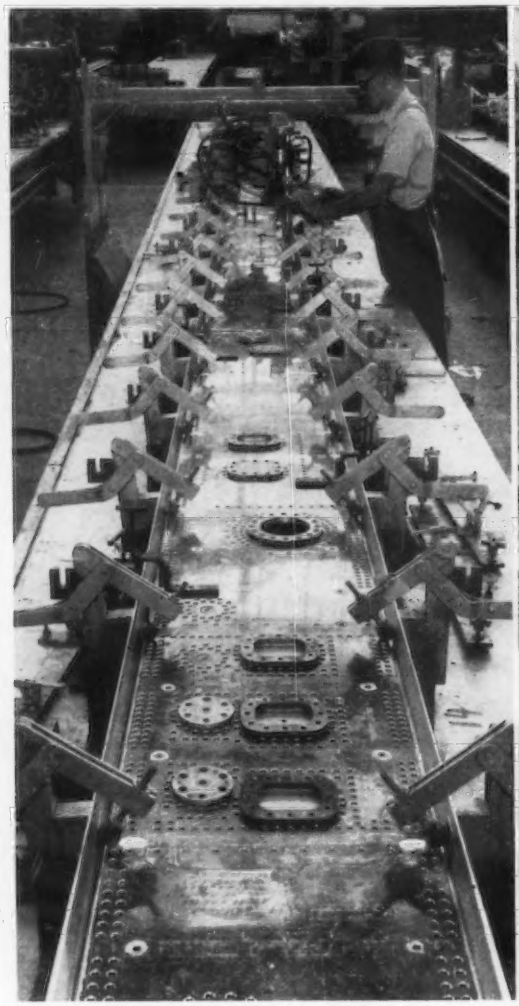


Wing spars are assembled in horizontal spar tables. Precision location of "erector set" holes assures that bulkheads will align.

Wing build-up
spar (foregrou
in position firs
then rotated i
wing station C

Convair 880 . . . continued

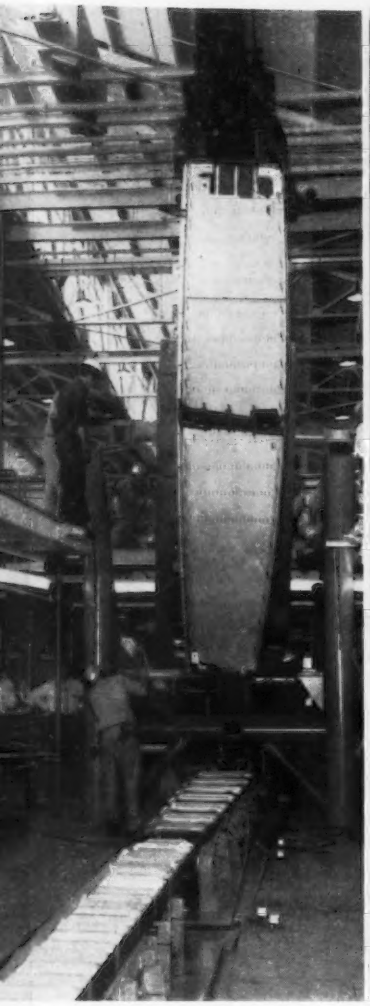
through the erector set holes. Rear spar is brought into position and located by the pre-coordinated holes in the wing bulkhead. After the wing bulkheads are attached, the skin and stringer panels are brought into position and the contour bars of the front and aft panels are mated before the skin and stringer panels are attached to the spars and bulkheads.

After assembly of the wing in the vertical buck, it is moved to the Scotchweld furnace area for final inspection, clean-up, and positioning in the oven to effect curing of adhesive on integral fuel tanks. Upon completion of the oven operation, the wing halves are rotated into flight position, and placed upon the mating station.

Mating of the right and left wing sections is accomplished by four coordinated holes located on front and rear spars using mastered plates. It was determined unnecessary to level the wing in the mating station, as component was being mated to component through previously coordinated holes. After the wing halves are mated, the entire wing proceeds to the first station of "wing primary," where the over-the-wing barrel, and under-the-wing canoe are joined.

Fuselage Details

The "tooling policy" for the fuselage is basically the same as that for the wing, i.e., mating components to components through mastered points, thus eliminating the use of complex mating stations and handling equipment.



ld-up is effected in bucks. Front
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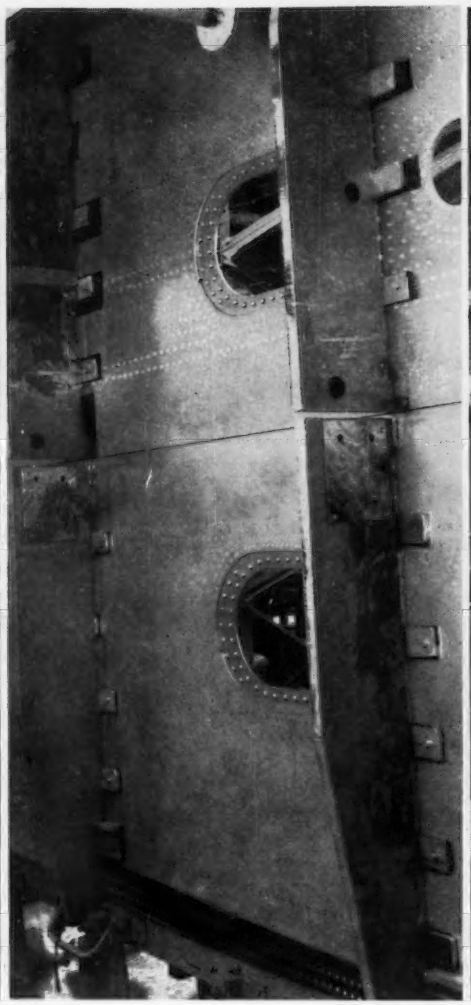
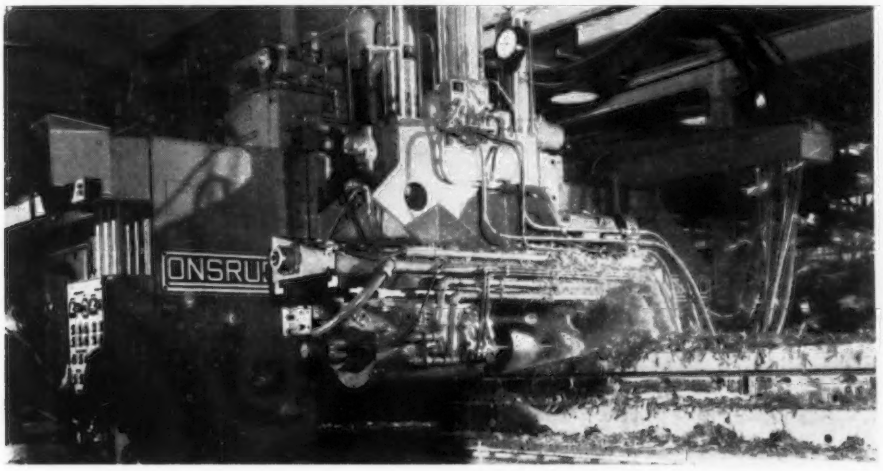


Wing skin-and-stringer panels are assembled in vertical fixtures. Contour bars are attached before panels are removed from fixture to await sequence in Erco Automatic Riveter.

Quackenbush self-feeding trim tool is used to "square" skins before butt joining individual fuselage sections. Tool rides on trim bars permanently attached to the fixture.

Special equipment procured for 880 production includes this electro-hydraulic, 150-ft bed Onsrud spar mill. Feed rates up to 300 in./min are possible.



Skin and stringer panels of the fuselage are assembled on vertical fixtures, and the skins are trimmed in the butt splice mating areas. Trimming is accomplished with a Quackenbush self-fed trimming tool, which rides on trim bars permanently attached to the fixtures. Final riveting of the skin and stringer panels is accomplished on either a General Drivematic or Erco Automatic Riveter.

The first major assembly of the fuselage nose section is accomplished in an upside down canoe fixture in which all beltframes or bulkheads are located. At each end of this fixture there are contour control accessory tools that hold the contour, and lift and turn the assembly 180 deg before it is placed in the nose buck. The aft contour control tool remains in the nose buck during the nose assembly and is removed before the nose goes to the pressure test station.

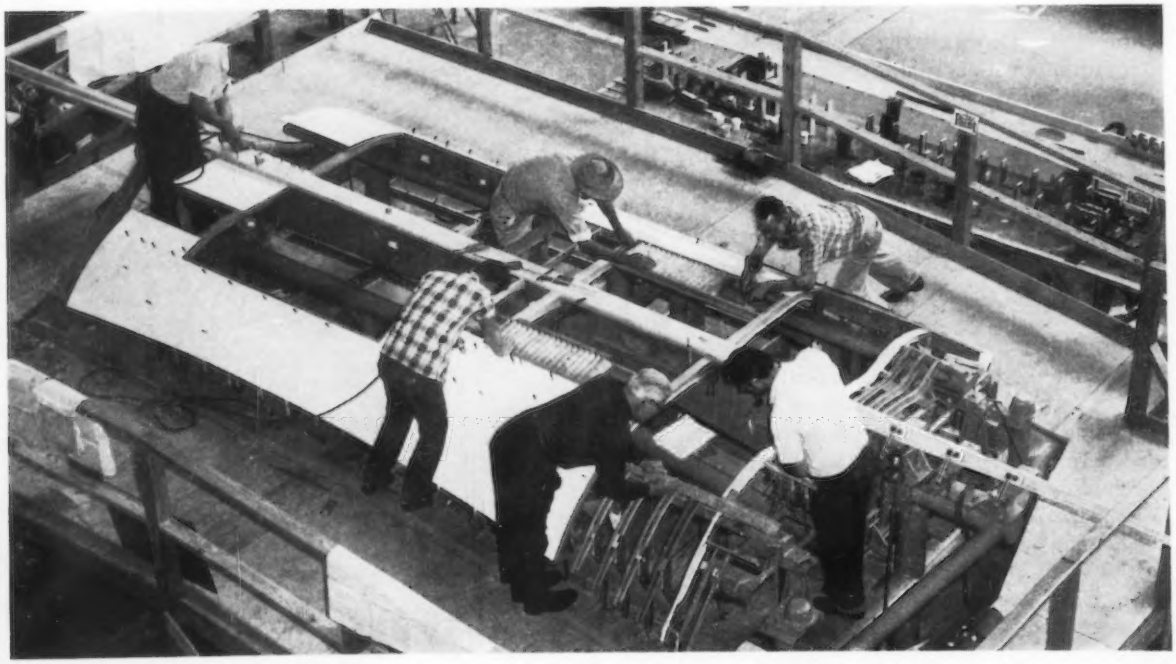
The sequence in the nose buck is to first locate the pilot's cockpit assembly in the fixture and bring the aft canoe on mating location using moving cradles within the buck. Station determination between the two assemblies is accomplished through butting of the skins, spacer bars, and radial location control bars. The completed nose assembly is removed to the nose pressure test station. Pressure testing is effected either with production or dummy doors. Final trimming of the nose skin, which is mated to the over-the-wing barrel, is accomplished in the pressure test station through the use of permanently attached trim bars which guide the Quackenbush self-fed trimming tools.

Tail Section

The tail section of the 880 consists of three major assemblies—aft lower canoe, aft canoe, and aft tail structure. The skin and stringer panels of the tail section are assembled in a manner similar to the nose panels. The forward section of the tail is assembled in an upside down canoe fixture with skins pretrimmed to net length in the skin and stringer panel fixtures. The aft canoe is assembled in an upside down canoe fixture with one contour control tool at the forward end; the aft end of this assembly is the pressure bulkhead. The aft tail structure is assembled in skin and stringer panel fixtures which are mated in a vertical teepee fixture before this assembly goes to the tail buck.

The first assembly placed in the tail buck is the aft tail structure and it is located by fixed locators. The aft canoe and aft lower canoe are placed on movable cradles on the tail buck, and the aft canoe is mated to the tail structure by piggy-backs which control the vertical stabilizer attach points. The aft lower canoe is mated to the aft canoe utilizing spacer bars, and radial control is accomplished by holding the relation-

Under-the-wing canoe is assembled in upside down fixture. Note 46 ft longeron through center of canoe. Contour control is of prime import.



Over-the-wing barrel is one of the first fuselage assemblies to be located in "wing primary." It is the major component for the control of fuselage to wing alignment.

ship of the cabin floor beams. Upon completion of this assembly in the tail buck, it is removed to "tail primary."

The first assembly of the fuselage that is located in wing primary is the under-the-wing canoe. This assembly is held in relationship to the wing through a fuselage bulkhead which has been previously attached to the center tie box front spar. The next assembly placed into position in the wing primary is the over-the-wing barrel assembly. Its control points are the relationship of the upper frame "I" beam to the front spar wing fittings, beltframe to wing fuselage dagger fittings, and main landing gear shear beam to main longeron of the under-the-wing canoe.

The next major assembly which is placed into position in wing primary is the auxiliary spar and trailing edge assembly which attaches to fuselage Station 926 and Station 224 on the wing. After this assembly has been installed the aft landing gear pivot bearing is placed into position with a mastered "A" frame which locates this bearing in relationship to the forward pivot bearing fitting and side brace fitting. The aft main landing gear pivot bearing is a self-aligned bearing encased in a rosette; thus no boring, reaming, or spot facing is necessary at the installation point.

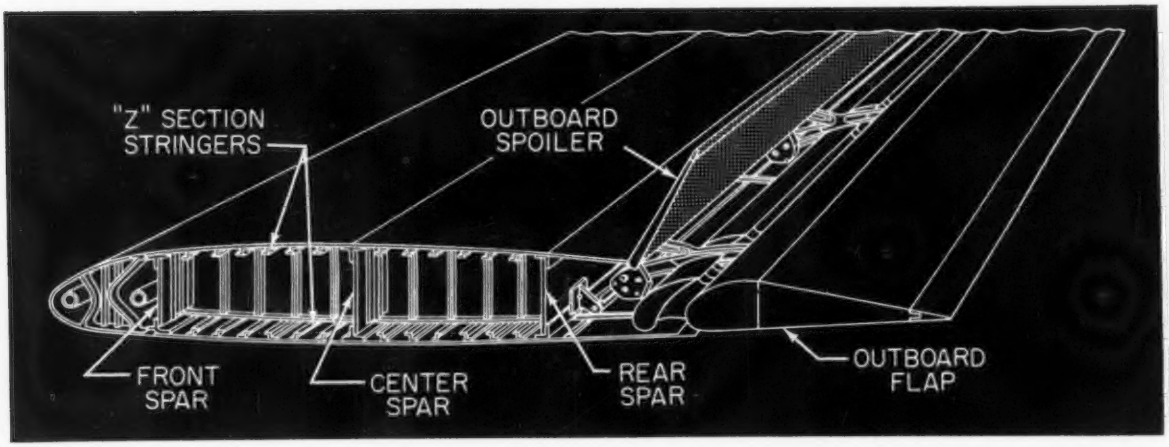
The next assemblies installed are the leading edge and trailing edge components fabricated by the Crosley Division of Avco.

After the leading edges have been installed in wing primary, the pod and pylon assemblies, fabricated by Rohr Aircraft Corp. are brought into position and attached through mastered holes. At the time of this assembly there is no drilling or reaming accomplished at the pod and pylon to wing attach points.

In "final mate," the nose and tail sections are mated to the over-the-wing barrel.

◆

Drawing shows location of three spars Auxiliary spar which supports main landing gear is not shown.



forging a renaissance in COPPER

THE BETTMANN ARCHIVE

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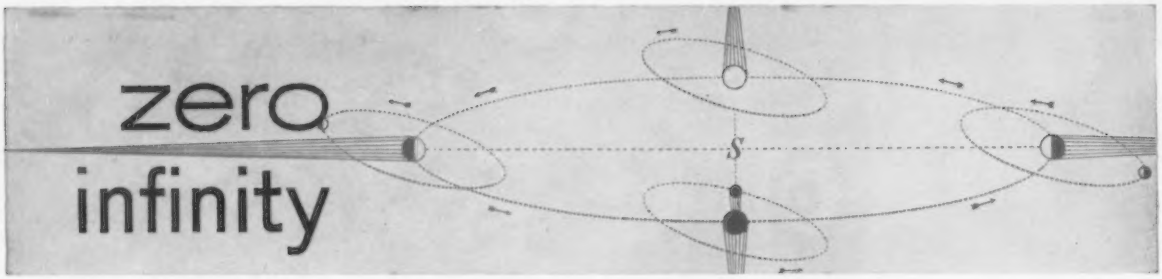
Circle 16 on Inquiry Card, page 81



This department is created to encourage thinking in new dimensions; thinking that is free of the often constraining influence of immediate difficulties. Technological progress is to a great extent based on departures from the conventional or the status quo. That which is considered illogical or impossible to accomplish, has and always will be so only within the limited compass of accumulated knowledge up to a particular date. Speculative thinking is man's most precious asset. It is hoped that this department will provide an outlet for such thinking and will serve to stimulate further ideas. The implications of the symbolism for this department head are that: while the immediate worth of a concept may range from nil to infinity, its true value will only be determined in the ultimate.

can the photoelectric process be used for

power stations on the Moon?

by **Dr. Peter A. Castruccio,** director
Astronautics Institute, Air-Arm Div.,
Westinghouse Electric Corp.

To achieve a true saving in interplanetary space travel, we need a base in the sky. A base capable of yielding its own rocket fuel, and possibly its own rocket structures. The only such base available to us today is the Moon.

To make the lunar surface a practical strategic base, and a jumping off station for further exploration of space, the Moon must thus be made to yield most of the materials required by space missions. This presupposes a Moon colony, with sufficient power to support life and industry in some measure similar to that on Earth.

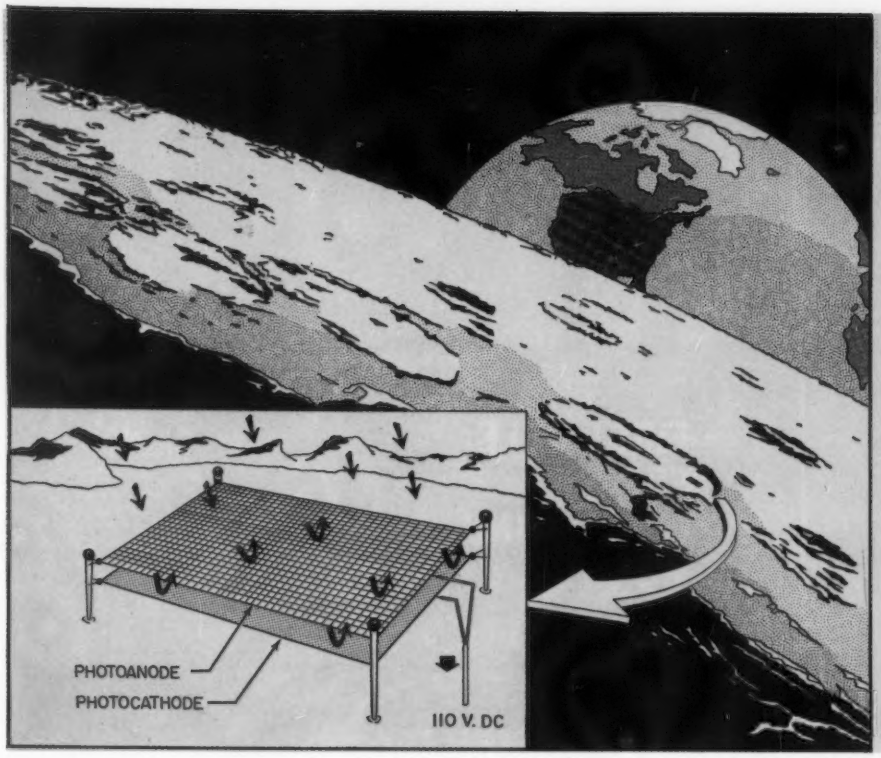
Sun As An Energy Source

At zenith the sun pours an estimated 6000 kw/acre upon the Moon's surface. Attempts to tap solar power have been made with varying degrees of success on our own planet for more than half a century. All of the devices constructed suffered from two drawbacks: fairly low efficiency, and sizeable weights.

The phenomenon of photoelectricity, discovered in 1887 by H. Hertz and not clearly understood until 1905, has never been used for the generation of power. One of the principle reasons for this is that photogeneration requires a vacuum. This is generally costly to achieve within our atmosphere. On the lunar surfaces, however, and in space generally, vacuum is freely supplied by nature. Photoelectric generation is thus a natural form of conversion of solar energy to electrical power in some environments. The Astronautics Institute of Westinghouse Air Arm Div. has proposed and is investigating this approach for an electrical power station on the Moon. The basic principle of photoelectric conversion is simple. A unit of light or radiation energy (a quantum) impinging upon a metallic surface extracts electrons from the metal if the energy of the quantum[1] exceeds the energy required to extract free electrons. The emitting surface is called the photocathode. If a collecting device is placed facing this surface, the electrons emitted by the photocathode will strike the collector photoanode and generate a voltage. Upon closing the circuit between photoanode and photocathode, current can be drawn. The impinging light energy is thus converted directly into electricity.

An obvious prerequisite for the generation of power is a low internal impedance for the device. Photoelectric cells which have been constructed in the past had internal impedances of the order of one megohm, and thus made available only microwatts. Work done at Westinghouse has yielded cells with internal impedances of about 3,000 ohms. Consequently structures

[1] *Energy in a quantum = hv, where h is Planck's constant (6.55 x 10 —27), and v is the frequency of the waves of radiated energy.*



By placing large photogenerators on Moon's surface, it may be possible to turn Sun's rays directly into electrical energy. Six thousand kw/acre are available at Sun's zenith. Lack of Moon atmosphere is main factor which turns thinking to photoelectricity.

have been developed which promise, in the near future, internal impedances of the order of 0.1 ohm.

The next important consideration is solar conversion efficiency. This depends on the "work function" (energy required to extract free electrons) of the materials used, since the higher the work function, the shorter the cutoff wavelength, and therefore the smaller the fraction of solar distribution spectrum that will be usefully converted. Efficiencies of the order of 0.1 per cent have been achieved. However, the insight gained shows promise of generators with up to 25 per cent conversion efficiency.

The Moon Power Station

Since the sun produces about 6000 kw/acre on the Moon's surface, achievement of a conversion efficiency near 25 per cent would mean power yields of the order of 1500 kw/acre at zenith.

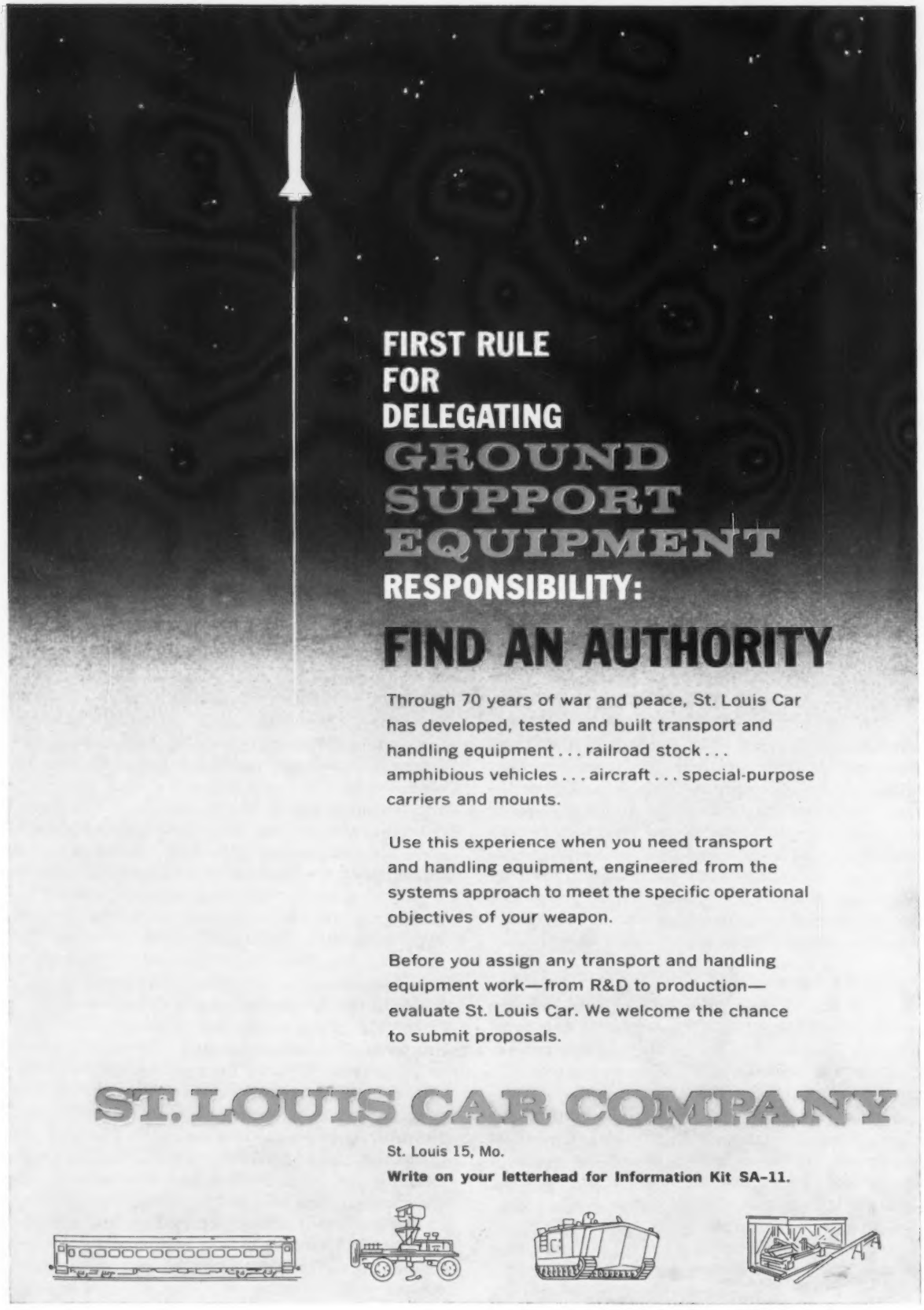
To construct a moon power station, Westinghouse has proposed to stretch thin plastic sheets between appropriate supports. Coated on the sheets will be an extremely thin layer (about one micron) of photosensitive material comprised of metallic mixtures.

After a thin metallic collector grid is placed facing the coated surface, but insulated from it, the cell will be complete. Since the voltage generated by each such cell is fairly low (order of a few volts), several cells will have to be connected in series. This can be done quite easily by separating the photocathode into individual sections, by insulating strips and connecting these sections in series. By this means, practically any voltage, including 110 v dc, can be obtained.

One of the chief advantages of this device is its exceedingly long life. Even relatively large meteorites impinging upon it would destroy only a portion of the photoconverting surface. There would be a small reduction in power output directly proportional to the area destroyed. To prevent meteorites from accidentally severing the power cables, these are envisioned as flat rather than cylindrical. A meteorite would merely punch a hole in the flat conductor without severing it.

The power yields quoted above are for the Sun at zenith. At angles other than zenith, yield would decrease directly proportional to the cosine of the angle from the vertical. A generator that could be oriented would alleviate this difficulty. However, while this is feasible in the case of photoelectric-equipped space craft, it is not practical for the large surface areas envisioned for the Moon. In this case, the extremely light weight of the generator allows for making the generator's surface larger to take into account the reduction factor caused by the sun's obliqueness.

✦



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AIRCRAFT & MISSILES MANUFACTURING DIGEST OF RECENTLY PUBLISHED TECHNICAL MATERIAL

producibility REVIEW

DESIGN

CONVAIR'S JET TRANSPORT FAMILY. *Aeroplane* (February 13, 1959), 6 pp. Design features of the 880 presented, together with a cut-away drawing.

BUILDING LIGHT INTO INSTRUMENTS. V. A. Orlando and J. J. Fraizer. *Mach. Des.* (January 8, 1959), 6 pp. Current methods and design considerations given.

POWERPLANT SURVEY. *Aeroplane* (February 6, 1959), 18 pp. Design trends, characteristic features, and performance data given for the world's major types of powerplants.

COOLING ORBITAL SPACE VEHICLES. J. S. Tupper. *SAE Journal* (January, 1959) 2 pp. Operational requirements are considered together with the merits of a water and ammonia evaporator system.

MATERIALS AND PROCESSES

HIGH-STRENGTH STEEL CAN BE CADMIUM PLATED WITHOUT EMBRITTLEMENT. D. J. Cash and W. Scheuerman. *Metal Progress* (February, 1959), 4 pp. The results of a cooperative investigation cited.

STATE OF THE ART: BERYLLIUM. I. Stambler. *Space/Aero.* (February, 1959), 4 pp. Some current applications and future possibilities discussed in the light of beryllium properties.

HOT ROLL-SPINNING. F. Spiegel. *Acft. Prod.* (February, 1959), 4 pp. Equipment and advantages presented for forming hemispherical parts.

HOT-FORMING TITANIUM WITH ADJUSTABLE-SECTION DIES. E. Selmer. *Tool Engr.* (February, 1959), 3 pp. Technique and equipment described for forming corrugations at 1200°F.

JOINING METALS WITH ADHESIVES. N. Ringueberg. *Tool Engr.* (January, 1959), 4 pp. Principles of oven and autoclave bonding discussed with case studies.

PRODUCTION

WHEN YOU SET UP FOR CHEMICAL MILLING. K. Clarke. *Amer. Mach.* (January 12, 1959), 4 pp. Discussion on the general scope of this process stating what is involved and the type of equipment needed to establish such a facility.

TOOLING FOR THE TITAN. F. J. Schu. *Amer. Mach.* (February 9, 1959), 4 pp. Operations and equipment used at the Denver plant of The Martin Co.

GET FASTER X-RAY INSPECTION WITH MOBILE CARRIAGE. W. G. Hitt. *Iron Age* (January 22, 1959), 2 pp. Description of method used by Douglas Aircraft Co., to inspect large missile tank welds.

BOOKS RECEIVED

CIVIL AIR REGULATIONS & REFERENCE FOR MECHANICS (14th Edition), *Aero Publishers Inc.*, 1958. 152 pp. $2.50. This compact volume offers all government regulations needed by aviation mechanics working on airframes or powerplants. Regulations governing glider airworthiness, rotorcraft airworthiness, mechanic and repairman certificates, flight engineer certificates, and general operation are also included. A list of 250 check questions is provided for mechanics who want to test their knowledge; instructions are given for obtaining inspection authorization.

ORDINARY DIFFERENTIAL EQUATIONS, by W. Kaplan. *Addison-Wesley Publishing Co.*, 1958. 534 pp. $8.50. This book is intended for those who already possess a basic knowledge of calculus; it is an introductory textbook dealing with the theory of ordinary differential equations from the point of view of "functional analysis." Applications of differential equations in physics and engineering are given, with treatment of aspects important for automatic controls, computers and servomechanisms. In the discussion of linear differential equations, the author follows an approach based on the notions of "input" and "output" associated with modern system analysis. Chapter coverage, in brief, includes the following: 1—Important concepts and main problems; 2—

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MOMENT IN HISTORY

THIS IS THE "FIRST FLIGHT" of the new Air Force TITAN, America's most powerful weapon and our No. 1 challenger in the big-missile field. Time: 2/6/59—4:22 p.m. EST. The most important thing about this moment in history is not visible here—and it is this: Three years to the day from the breaking of ground at Martin-Denver, TITAN No. 1 roared into the sky. Those 36 months saw the creation of the free world's most advanced ballistic missile facility—and the development, production, testing, delivery and launching of the first of an entirely new generation of ballistic missile weapon systems, forerunner of the Global Ballistic Missile. TITAN is the result of an advanced engineering concept—developed by Martin under the direction of the Air Force's Ballistic Missile Division of the Air Research and Development Command—which provides the most extensive pre-flight testing of components, subassemblies and full scale missiles ever undertaken. This method in the TITAN development, and in the generations of space systems to follow, may well be one of the most important single factors in speeding America's bid for space supremacy.

Equations of first order and first degree with special devices for solving problems in explicit form; 3—Detailed study of the first order linear equation from the point of view of input and output; 4—Linear equations of arbitrary order, with emphasis on those with constant coefficients; 5—Input-output analysis extension to linear equations of higher order; 6—Simultaneous linear equations, methods of solution and applications; 7—Integrals of differential equations of arbitrary order; 8—Equations not of first degree; 9—Thorough treatment of power series solutions; 10—Numerical methods for obtaining solutions; 11—Phase-plane analysis; 12—Proofs of the main theorems.

PLANE CRASH! by Clayton and K. S. Knight. *Greenberg*, 1958. 213 pp. $4.50. A readable account of how airplane crashes are investigated, and seemingly insignificant bits of evidence are pieced together to detect causes. Some of the widely publicized air disasters of recent years are used here to illustrate the extent of detective work used. Photographs, diagrams, and maps are included to amplify case histories.

U. S. AIRPOWER, by S. T. Moore. *Greenberg*, 1958. 196 pp. $5.95. This is a thoroughly illustrated account of the growth of airpower, and the part it has played in shaping the future. This is a story of great accomplishments as well as of human failure—failure to appreciate certain significant phases of air-weapon development. Here is a record of controversies which have flared periodically and the way they have influenced our military posture. Material presented in this book can serve as a basic orientation for students of airpower concerned about the near future.

REVIEWED IN THIS ISSUE

periodicals and papers

Acft. Prod. Aircraft Production (British)
Aerop. The Aeroplane (British)
Amer. Mach. American Machinist
Iron Age. The Iron Age
Mach. Des. Machine Design
Mtl. Prgs. Metal Progress
SAE Journal. Society of Automotive Engrs. Journal
Space/Aero. Space Aeronautics
Tool Engr. Tool Engineer

BOOKS RECEIVED

Civil Air Regulations & Reference for Mechanics Aero Publishers Inc.
Ordinary Differential Equations. Addison-Wesley Publishing Co.
Plane Crash! Greenberg
U. S. Airpower. Greenberg

Martin-Denver
is one of the
seven divisions
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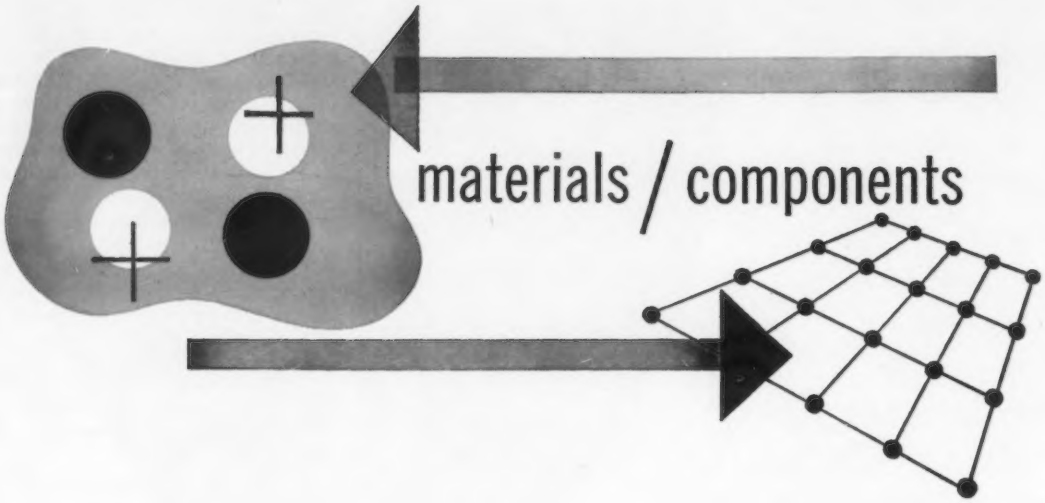


FLUORINATED ALCOHOLS HAVE LUBE POTENTIAL

Highly fluorinated alcohols hold some potential as lubricants for use at the elevated temperatures.

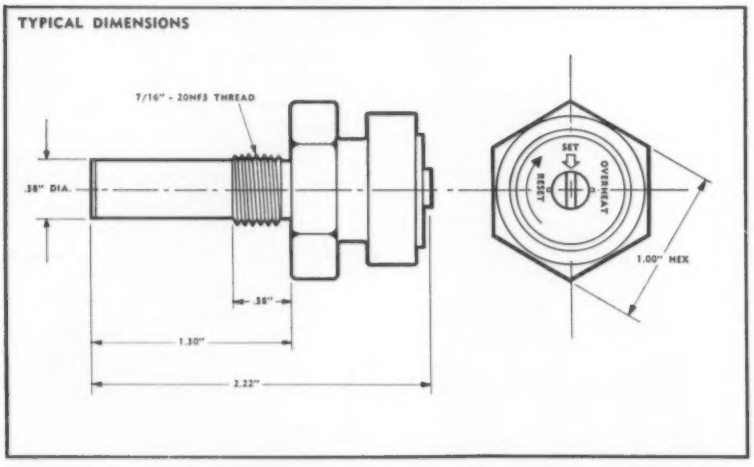
Oxidation tests on fluoroesters indicate a camphorate can be used at bulk oil temperatures up to at least 400°F., while a fluoroalkyl pyromellitate extends the useable temperature range another 100°F.

A jet engine in which fluoroalkyl camphorate was used as a lubricant was found to be "very clean" after a 100 hr run at a bulk oil temperature of 300°F.

E. I. du Pont de Nemours & Co.

Circle 51 on postcard for more data

OVERHEAT INDICATOR



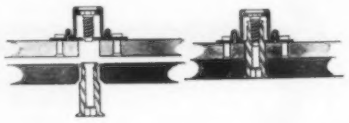
Recent development is an overheat temperature indicator, used to detect an overheat condition which may have occurred in an engine during flight. It provides an easy visual check by the ground mechanic after flight. The indicator is held by an eutectic metal designed to liquefy at a special temperature. After use the indicator is easily reset for the next flight.

Barber-Colman Co.

Circle 55 on postcard for more data

PANEL FASTENER IS QUICK OPERATING— AND SELF-LOCKING

Structural panel fastener is available in two lug and corner mounting styles. A



unique characteristic is the self-jacking action of the sleeve bolt which eliminates binding problems when removing panel. This fastener permits panel misalignment of as much as .040 in. per hole and closes gaps up to 1/8 in.

Fail safe construction prevents over torquing.

Nutt-Shel Co.

Circle 54 on postcard for more data

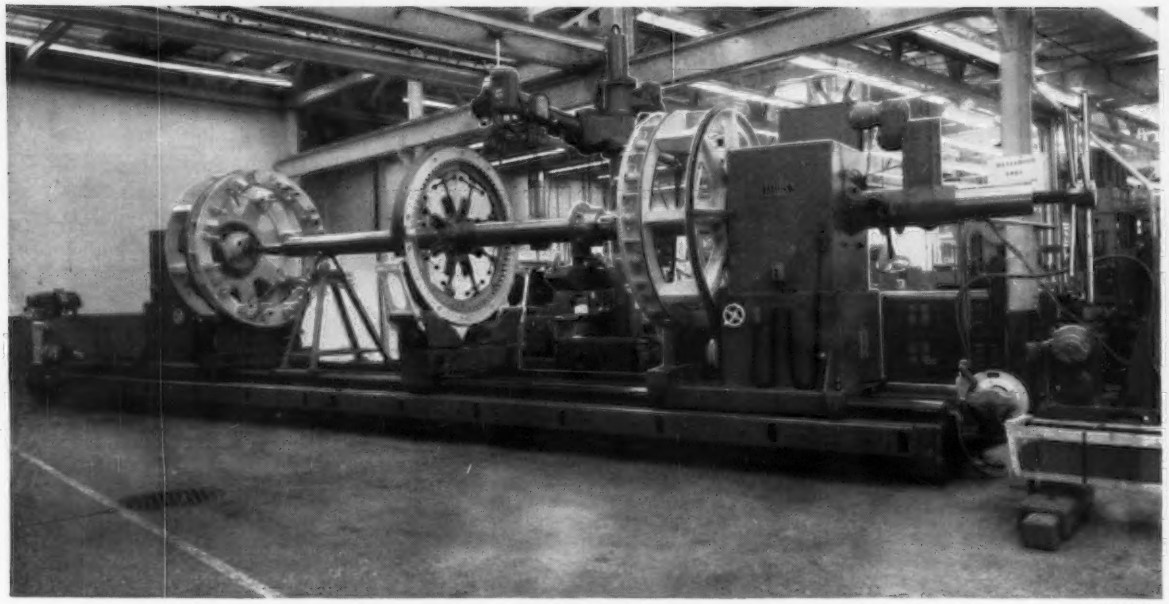
EPOXY NOVOLAC RESIN HAS PHYSICALS

A new epoxy novolac differs from conventional epoxies in that it is based on epichlorohydrin and novolac rather than epichlorohydrin and Bisphenol-A.

In addition to its greater heat stability and strength at high temperatures, X-2638.3

continued on page 52

(Advertisement)



8474-LW

new tooling concepts facilitate automatic welding of thin-skinned missile structures

Custom engineered tooling "packages" successfully adapt advanced automatic welding techniques to missiles manufacturing.

Even though critical strength-weight ratios in air weapons systems components are being resolved by new lightweight structures and materials, the fabrication of these complex structures still is a problem. Standard tools and production methods are not versatile enough to meet their extreme tolerances.

In automatic arc welding, a basic method of fabricating ultra-thin sections, arc control has evolved to a high level of reliability. But practical application of advanced automatic welding techniques becomes feasible *only through custom tooling.*

The special machine illustrated above is an example of the advanced state of this art. Designed, engineered and built for a specific purpose, it is used to fabricate large-diameter thin-gauge missile fuel tanks from special alloy steels.

For this particular project, massive tooling was required to position, support and rotate fragile preformed tank sections under an automatic welding head. Because of prior finishing, each section had such substantial "added value" that the margin for error was zero.

The specialized tools and fixtures were designed and built to rigid specifications that assured machine tool accuracy.

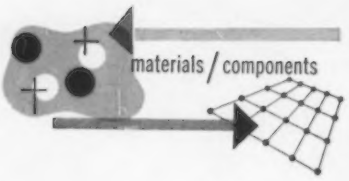
This type of packaged precision tooling is a specialty with Lewis Welding & Engineering Corp. A production fabricator with more than 20 years' experience, Lewis offers coordinated design, engineering and manufacturing services. This versatile design-and-build capability is based on fully integrated facilities under one quality control responsibility.

If fabricating thin-skinned birds . . . or their components . . . is causing you problems, Lewis has diversified experience in developing tools, fixtures and manipulating equipment for automatic welding processes. Our engineers will be glad to discuss your requirements and to make recommendations.

THE LEWIS WELDING & ENGINEERING CORPORATION
108 Northfield Road • Bedford, Ohio

Designers • Engineers • Fabricators • Machinists

Circle 22 on Inquiry Card, page 81



exhibits more chemical resistance than conventional resins.

Typical uses are in high strength adhesives for metal fabricating, glass reinforced laminates for structural shapes, and electrical printed circuits.

X-2638.3 is available also in an 85 per cent solids solution to facilitate handling by fabricators.

Dow Chemical Co.

Circle 59 on postcard for more data

AIR PRESSURE SWITCH FEATURES RELIABILITY

A switch for precisely indicating absolute air pressure in both airborne and ground support equipment features small size and reliability.

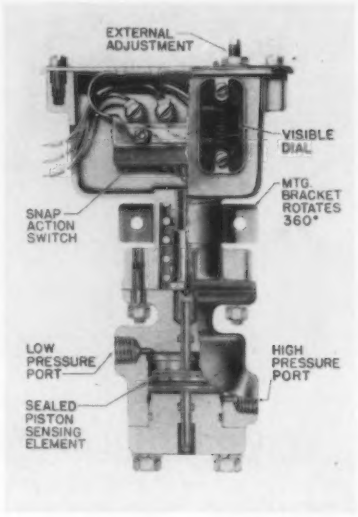
Standard model is available in the range 0.4 psia to 15.0 psia. Other units available in ranges 0.1 to 1.0 psia and 13.0 to 20.0 psia. Electrical contact rating is 2.0 amps at 30 vdc and 3.0 amps as 115 vac. Contact is available either normally open or normally closed. Operating temperature range is —65 to 220°F. Deadband is 0.5 per cent. Accuracy and repeatability is 1.0 per cent. Unit weighs 3.7 oz.

Aero Mechanism, Inc.

Circle 60 on postcard for more data

PRESSURE SWITCH SENSES DIFFERENTIAL OF 5 TO 140 PSI

Particularly suitable for filter installation, a pressure differential switch has been announced by Barksdale Valves.



Unit is constructed to sense a difference from 5 to 140 psi.

When a filter becomes clogged, the switch senses the pressure difference across the filter's inlet and outlet and actuates a warning circuit.

A sealed piston sensing element actuates an electric circuit upon increasing or decreasing of a predetermined pressure difference.

Barksdale Valves

Circle 61 on postcard for more data

SLIP RING ASSEMBLY HAS LOW NOISE LEVEL

With all 40 circuits tied in series and with 50 milliamps of current flowing through its 40 slip rings the total noise in a new low torque assembly remains under 2 millivolts. This condition is repeatable even after 1000 hours of operation at 500 rpm, under vibration conditions of 10 cycles per second.

The breadaway friction level of the 40 circuit assembly, including ball bearings, is kept under 75 gram centimeters.

The capacitance is less than 20 micro microfarads and the insulation resistance is greater than 5000 megohms circuit to circuit and circuit to ground.

Slip Ring Company of America

Circle 52 on postcard for more data

ADHESIVE BONDS VITON ELASTOMER TO METALS

Chemlock 607 is an adhesive for bonding the fluorocarbon elastomer, Viton A, to steel, copper, brass, aluminum, titanium, magnesium, chrome-plated steel and other substrates.

Chemlock 607 is a clear, colorless liquid adhesive.

Lord Manufacturing Co.

Circle 50 on postcard for more data

POPPET VALVE FOR ELECTRONIC CONTAINERS

Designed as a safety pressure relief mechanism, a miniature precision poppet valve is now available.

The light weight valve, 7.4 gm, is bulkhead mounted. The need of bosses, brackets or threads is thus eliminated. Silicone rubber "O" ring seal is

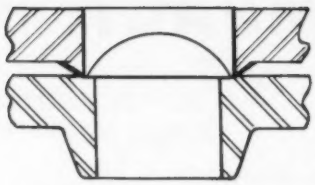
used. The valve is factory preset to customer requirements within pressure range at 1 to 20 psi.

Glaeser Engineering

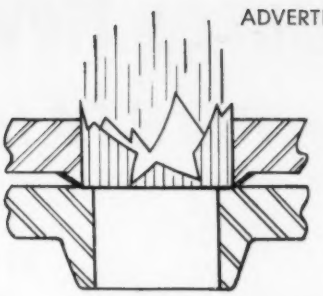
Circle 63 on postcard for more data

continued on page 55

ADVERTISEMENT



As long as pressure remains below the pre-determined point at which the dome-shaped disc will rupture, a leak tight seal is maintained.



When pressure attains the rated rupture point of the disc, instant release is provided through full orifice diameter by the outward bursting of the rupture disc.

An Advanced Approach To Pressure Systems Design

How To Reduce Weight Factor In Pressure Release Mechanisms

Although BS&B Safety Heads, in one form or another, have been providing over-pressure protection for closed pressure systems in numerous industries for more than 25 years, it is only recently that they have come into their own as pressure release devices for various types of airborne equipment.

Recent metallurgical and engineering developments, as well as improved manufacturing procedures, have made the BS&B Safety Head today's lightest weight, most accurately calibrated pressure release device ever developed. A typical Safety Head consists of a metal rupture membrane secured in mounting flanges. There are no moving parts.

Weakness A Virtue

The rupture membrane, or disc, is a purposely designed "weak spot" in the pressure system. Over-pressure bursts it at a pre-determined set pressure rating.

Full relief area is achieved instantly. When the disc ruptures a full throated opening is provided. This outstanding feature is most advantageous in pressured systems where ignition or exothermic reaction during a process causes abnormal pressure rise in seconds or milliseconds.

... This briefly, is the function of a BS&B Safety Head as related to over-pressure protection.

Imagination The Only Limiting Factor

The application and design of Safety Heads is continually being expanded. BS&B Safety Heads are serving the aircraft and missiles industries in ground, air and marine applications.

As an example ... visualize the rupture disc as a seal to retain pressure in a chamber, and actuated (burst) by pressure developed within seconds or milliseconds. The pressurized fluid is thus discharged into another chamber. Here ignition may take place with contact of another fuel component. Chemical reaction may instead serve to further energize the system.

As a different application of the same basic device, the rupture disc of a Safety Head could serve as a signaling device ... or to retain pressure to a pre-determined point whereupon it would then be actuated by an explosive squib or primacord.

Peculiarly Suited To Airborne Mechanisms

Weight is of prime concern in airborne equipment. The smallest Safety Head now in production weighs only a fraction of an ounce. It is about the size of a large pea. In spite of its minuscule specifications it still retains all of the design features and precise operating characteristics so essential to satisfactory performance.

Big Or Little, High Pressure Or Low

BS&B Safety Head sizes range from ⅛" to 44" in exposed diameter of the rupture disc. Pressure rating for the disc can be anywhere from 5 psi. to 100,000 psi. Mounting flanges and rupture disc metals can be varied over a wide selection to accommodate exposure to acids or other corrosive conditions as well as to elevated and sub-zero temperatures.

Hundreds Of Design Variations Possible

If you need pressure release devices of small size and light weight for missiles and JATOS, or large sizes for ground fueling systems and engine test facilities, you should examine the advantages of using BS&B Safety Heads. Chances are there is a Safety Head of the necessary characteristics available from present designs. If not, it can be custom built to your specifications.

Here then are just a few of the reasons why BS&B Safety Heads can serve you better in many different applications...

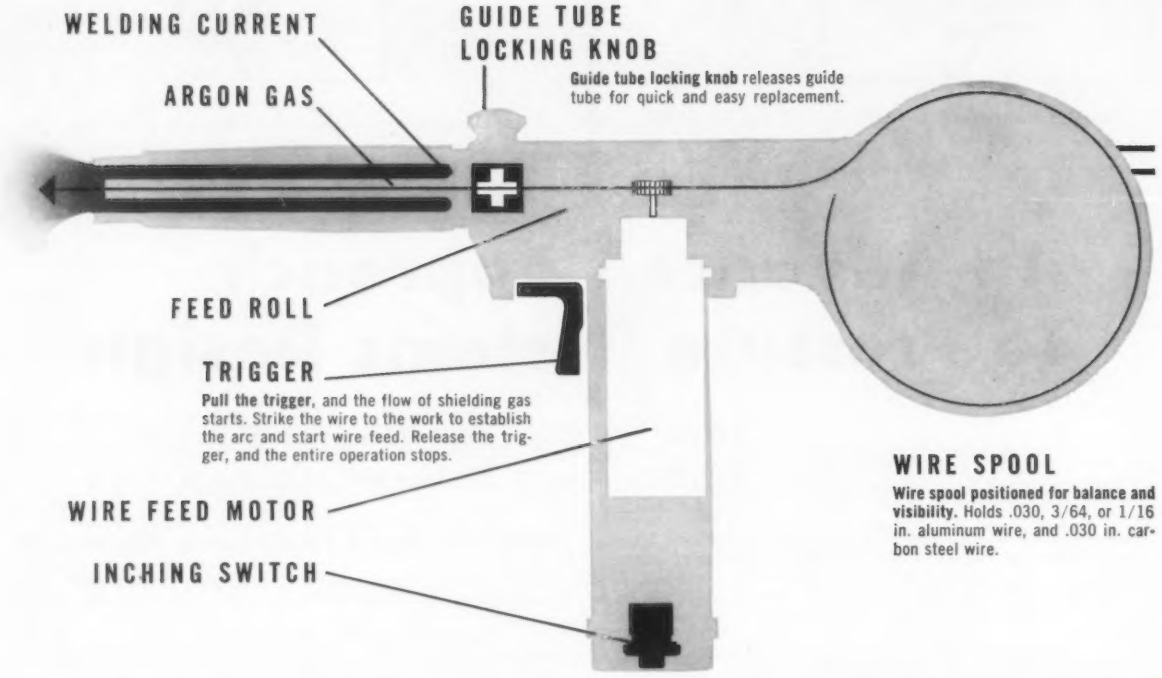
- A pressure relief device with controlled release accuracy.
- Leak tight.
- Light weight.
- No movable parts.

For answers to your specific questions contact the Safety Head Division at the General Offices in Kansas City, or the BS&B Field Sales Office or Sales Agent located nearest you.

BLACK, SIVALLS & BRYSON, INC., Safety Head Division, Dept. 2-GC4
7500 East 12th Street, Kansas City 26, Missouri.

Circle 23 on Inquiry Card, page 81

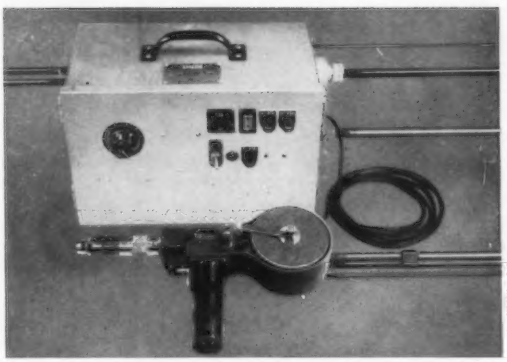
Try LINDE'S New "SIGMETTE" Torch!
—PORTABLE, COMPACT


WELDING CURRENT
ARGON GAS
GUIDE TUBE LOCKING KNOB
Guide tube locking knob releases guide tube for quick and easy replacement.
FEED ROLL
TRIGGER
Pull the trigger, and the flow of shielding gas starts. Strike the wire to the work to establish the arc and start wire feed. Release the trigger, and the entire operation stops.
WIRE FEED MOTOR
INCHING SWITCH
WIRE SPOOL
Wire spool positioned for balance and visibility. Holds .030, 3/64, or 1/16 in. aluminum wire, and .030 in. carbon steel wire.

Here's the torch that goes to the job—lets you work in any position . . . in confined spaces . . . at distance remote from the power source!

Designed for Sigma welding of light metals, the "Sigmette" torch is compact and sturdy. Notice the thin silhouette and position of the spool for complete visibility. Torch and control are completely insulated and grounded—the operator is protected from electrically "hot" parts. And the only maintenance tool needed is a screwdriver!

Find out how Linde's new "Sigmette" torch can speed your operations, bring new economies through its advanced design features. For a free demonstration and detailed information, mail the coupon today or call the nearest Linde Office.



Complete unit—torch weighs 3 pounds, 1 oz.; control weighs 19 pounds, 2 oz.; Current rating, 125 to 200 amp.; Welding power, direct current reverse polarity

Dept. AC-4, Linde Company
Division of Union Carbide Corporation
30 East 42nd Street, New York 17, N. Y.

☐ Please send complete facts on the new "Sigmette" torch.
☐ Please arrange to let me try it.

Name_____

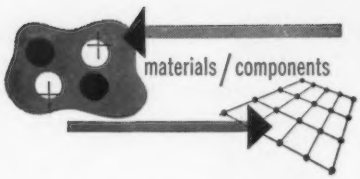
Firm Name_____

Street_____

City_____ Zone_____ State_____

"Linde", "Sigmette" and "Union Carbide" are trademarks of Union Carbide Corporation.

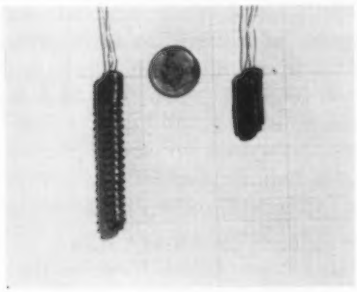
Linde UNION CARBIDE



TINY BELLOWS MOTOR PROVIDES HIGH THRUST

A powerful, miniature, squib-actuated bellows motor has been designed to provide positive displacement for mechanical work.

The motor has a 0.320-in. diam. and is 1 in. long. It is actuated by as little as 100 ergs at 1.5 v, or 0.3 amps. The motor



is capable of providing 10 lb of thrust over a 1-in. minimum stroke within an elapsed time of 1 millisecond. Bellows can deliver power when bent 90 deg.

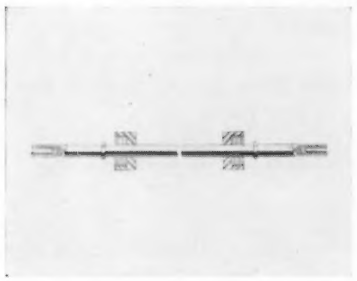
Motors function from —65 to 165°F and will withstand 20,000 g's shock and acceleration.

Atlas Powder Co.

Circle 56 on postcard for more data

SILICONE GLASS FIBER IN NEW WIRE TERMINAL

A new lead and terminal



for high altitude and high voltage in 12,000; 25,000; and 35,000 ratings at 5 amp is available.

The leads are made of silicone rubber insulated wire. The terminals are made of epoxy and glass fiber or ceramic materials, depending upon performance specifications.

Capitron Div.

Circle 62 on postcard for more data

VACUUM CONNECTORS FLEXIBLE, STAINLESS

Vacuum-tight flexible connectors serve the dual purpose of isolating vacuum systems from vibration and facilitating assembly.

Designated Series 5039, they are available in 2, 3, 4, 5, 6, and 10 in. pipe sizes. Each connector consists of a stainless steel bellows and two flanges,

one of which, in all but the 10-in. size, is constructed to facilitate assembly of two components which may have different bolt hub orientation.

NRC Equipment Corp

Circle 53 on postcard for more data

TAPE PROGRAMMER HAS 13 CHANNELS TO .6 MIN DURATION

A 13-channel tape programmer has increased tape capacity up to 160 ft of 35 mm Mylar tape, thus giving a program duration of 10.6 min at a transport speed of 3 in./sec.

The MLPR-13 is an electro-mechanical device. It operates by providing electrical pulses at pre-determined, controlled intervals through 13 independent channels. A sensing

device reads pulses through slots punched in a 35mm insulating tape (Mylar) which is drawn past the sensing device.

Beattie-Coleman Inc.

Circle 57 on postcard for more data

HI-TEMP PUMPS HAVE HI-SPEED RELIABILITY

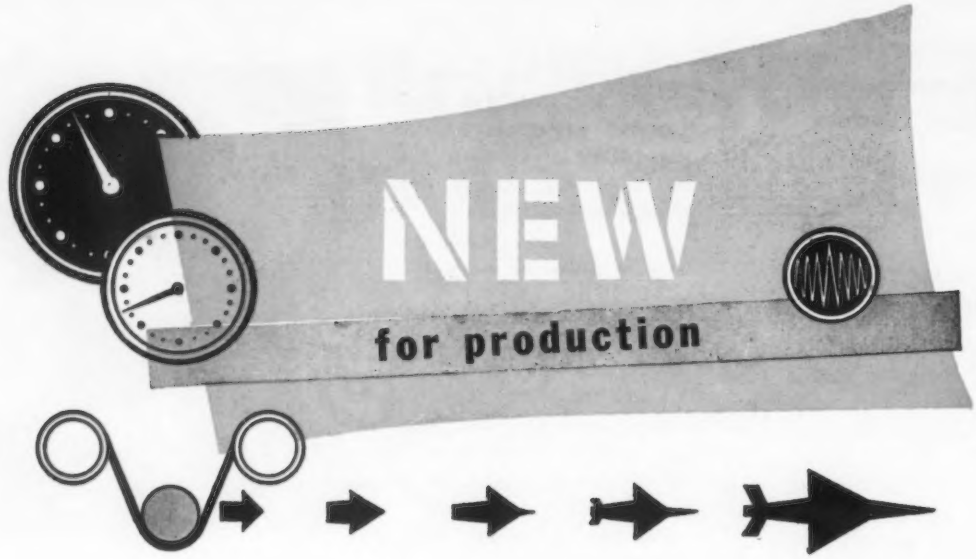
A line of constant pressure, variable displacement, piston type hydraulic pumps has been developed for high-temperature applications in aircraft and missile hydraulic flight control systems.

Pump design features increased reliability at higher operating speeds, insensitivity to fluids, high-temperature bearings, all-metallic O-rings and seals, and a minimum of rotating parts.

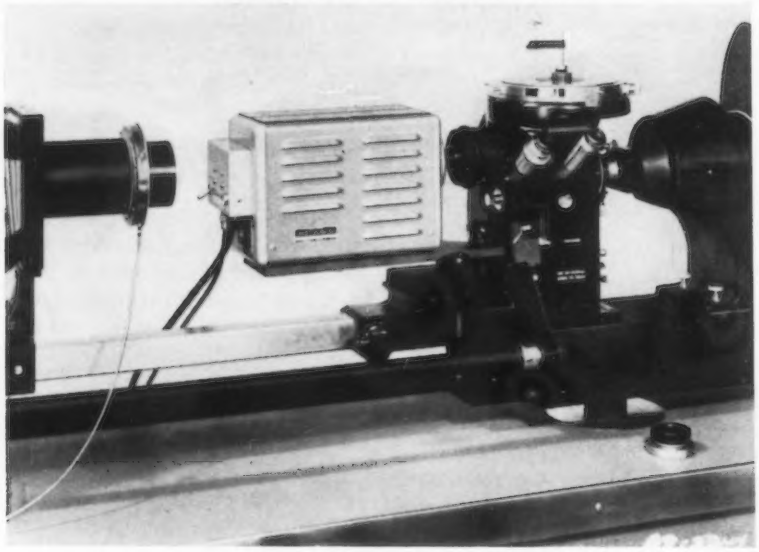
Available with either single or dual pumping elements, the pumps are designed to run at speeds up to 7500 rpm, and fluid temperatures up to 550°F.

Pesco Products Div.
Borg-Warner Corp.

Circle 58 on postcard for more data



TELEVISED METALLOGRAPHY



This closed circuit television unit for metallography produces illuminated microscopic images enlarged on one or more 21 inch monitor screens.

Camera, an automatic compensating type, is mounted on special bracket to fit the metallograph. A vertical stand with bracket is also available to hold the camera over a table microscope having a vertical eyepiece tube.

The compensating feature tends to keep brilliance of the image constant regardless of light level. Filters in the microscope and other microscope controls are used for gross light adjustments.

Additional feature—camera may be removed from microscope and equipped with tripod and one or more photo lenses. Unit can then be used for closeup inspection of hard-to-approach locations or for transmitting information from one point to another.

Contrast will be sufficient at all magnifications with any modern metallograph using carbon, tungsten, zirconium, or xenon arc lamps—also with metallograph using ribbon filament incandescent bulb.

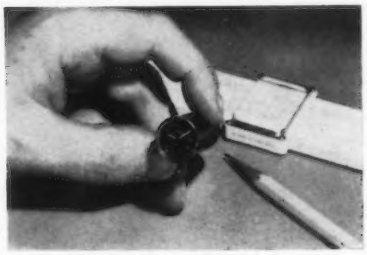
Box-like equipment in center of illustration is camera. At left, standard camera which can be used when TV unit is not operating. At right, microscope focused on round blocks specimen. Screen for projection is attached above it. Monitor is not shown.

Adolph I. Buehler Inc.

Circle 67 on postcard for more data

RELIABILITY FACTS

Elapsed time indicator is size of dime, weighs 1.2 oz, is



ideal for black boxes of components for life-reliability information.

Tiny electric motor inside draws only 0.018 amp at less than one watt.

Elgin Micronics Div.

Circle 71 on postcard for more data

TRANSISTOR TESTER

First tester capable of checking the performance of transistors while they are connected within their circuits is being produced.

Unique combination of transistor circuits, developed under a Navy contract, resulted in this technical breakthrough.

Previously, transistors had to be taken from their soldered places for testing. New tester is about the size of two cigar boxes.

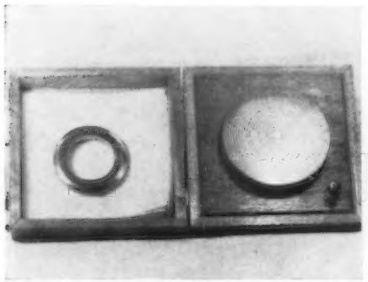
Philco Corp.

Circle 72 on postcard for more data

LAPPING PLATES FOR PRECISION SURFACES

Accurate surface flatness and mirror finish are the basic blocks for many of today's precision requirements. Diamond-impregnated lapping plates make it possible to lap surfaces a few thousandths of a square in., to about a square ft in area. A 2 to 4 micro inch finish and a surface flatness of ½ to 1 light band (0.000006-0.0000116) are attainable with these plates.

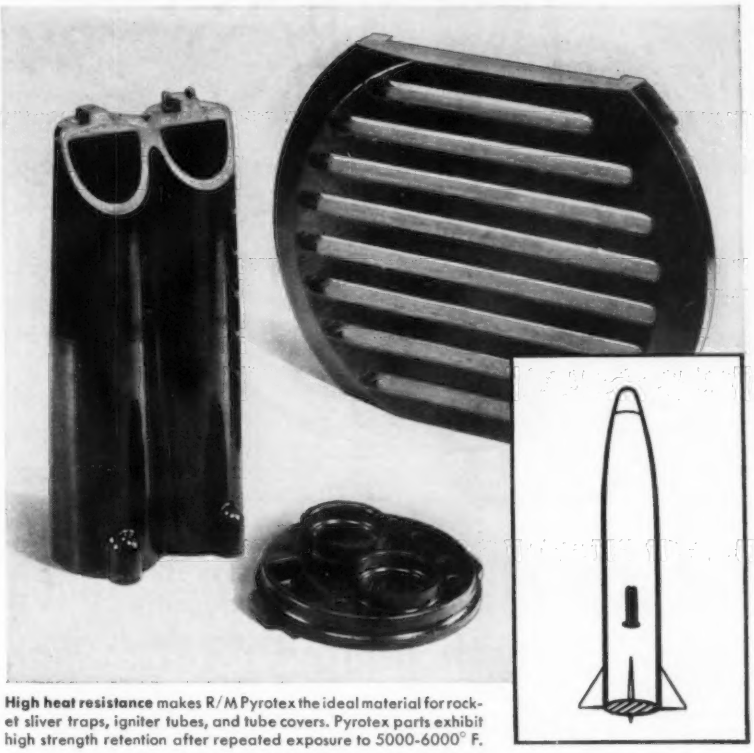
Typical applications include the following: reconditioning of gage blocks, snap-gage surfaces, and test equipment anvils; surfacing of accurate dies and mechanical



seals; finishing of electronic component contact surfaces and

R/M PYROTEX® REINFORCED PLASTICS ... DEVELOPED TO ENDURE THE FIERY REALM OF THE ROCKET

Light, strong, heat resistant . . . for low-cost, precision fabricated rocket parts— both structural and aerodynamic



High heat resistance makes R/M Pyrotex the ideal material for rocket sliver traps, igniter tubes, and tube covers. Pyrotex parts exhibit high strength retention after repeated exposure to 5000-6000° F.

Looking for a material that will withstand the elevated temperatures generated by missiles and rockets—internally from burning propellants, externally from aerodynamic heating? Must this material have good insulation and thermal properties, chemical and water resistance, and take a smooth finish? If so, one of R/M's family of Pyrotex reinforced plastics may be the solution to your problem.

The many outstanding thermal and structural features of R/M Pyrotex have led to its use on almost every U.S. missile. It has been fabricated into parts such as nose cones, fins, igniter tubes, rocket throats and sliver traps. Its exceptionally good dimensional stability makes possible mass production to precision standards. And it is low in cost. Write for additional information.

RM

RAYBESTOS-MANHATTAN, INC.

REINFORCED PLASTICS DEPARTMENT, Manheim, Pa.

FACTORIES: Manheim, Pa.; Bridgeport, Conn.; Paramount, Calif.; No. Charleston, S.C.; Passaic, N.J.; Neenah, Wis.; Crawfordsville, Ind.; Peterborough, Ontario, Canada

RAYBESTOS-MANHATTAN, INC., Asbestos Textiles • Laundry Pads and Covers • Engineered Plastics • Mechanical Packings • Sintered Metal Products • Industrial Rubber • Rubber Covered Equipment • Brake Linings Brake Blocks • Abrasive and Diamond Wheels • Clutch Facings • Industrial Adhesives • Bowling Balls

Don't get lost in a maze of wires!

Cut cost of assembly by as much as 65%, with printed circuits on TAYLOR copper-clad laminates

Conventional circuitry is a maze of wire and spaghetti. It is costly to assemble and unpredictable in performance. A printed circuit on TAYLOR rolled copper-clad laminate is a strong prefabricated part of known reliability. This quality is largely due to the new finish on the copper. Both solder and ink go on uniformly. The handling of one part alone can cut assembly costs as much as 65%. And there is an important passalong benefit: field repairs, when necessary, can be made easier and more economically. Write TAYLOR FIBRE CO., Norristown 50, Pa., for complete details.

Taylor

LAMINATED PLASTICS VULCANIZED FIBRE

metallurgical specimens.

The hardest tool steels such as Stellite and Hastealloy, ceramic materials and nonferrous metals may also be finished by this lapping process.

Crowe Tool Co.

Circle 68 on postcard for more data

MINIMUM SIZE WELDING TORCH

This is improved version of inert gas shield welding torch developed to repair difficult locations in turbines.

Aircooled 2¾ oz torch handles from five to 150 amp. Process employs an arc between workpiece and a non-consumable tungsten electrode. Three electrode sizes and eight gas cup styles and sizes give needed versatility.

Wilson Equipment Corp.

Circle 73 on postcard for more data

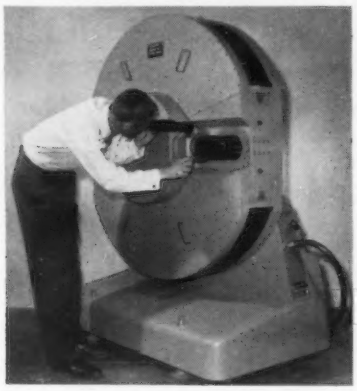
FRAMING CAMERA

Model 192 continuous-writing framing camera is designed to accommodate magnification-velocity products up to 3 mm per microsecond. At conventional magnification it records object velocities to Mach 35.

Instrument operates with no blind time. It can be used to photograph high-speed events which do not lend themselves to

synchronization with the position of the rotating mirror in the camera.

Because of this feature, the model is ideally applicable to high-speed aerodynamic studies,



for thermal-barrier studies in ballistic investigations (such as nosecone re-entrance problems), for hypersonic wind tunnel instrumentation, and for exploring the behavior or rocket propellants, etc.

Beckman & Whitley, Inc.

Circle 64 on postcard for more data

GLASS GAS FURNACE

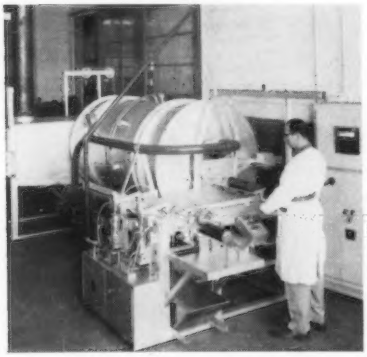
New Bal-Tate glass gas furnace processes and removes glass layer from billets by automation.

Furnace may be used for extrusions, forgings, forming, rolling, and soaking.

Advantages include no scale, odor, fuming; hot pickling of the billets; use of any type gas; use of scrap glass giving higher heating of the steel.

Bal-Tate Furnace Co.

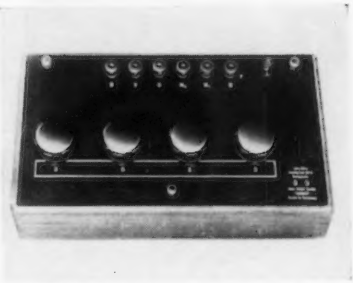
Circle 66 on postcard for more data



FOUR DIAL RATIO SET

Four dial direct reading ratio set has a precision of 1 ppm. It affords easy, quick, and precise method of comparing high precision resistors against known standards. Set is encased in a polished mahogany box with removable cover.

Physics Research Laboratries Inc.



Circle 70 on postcard for more data

continued on next page

ALL THE PRODUCTION YOU'LL EVER WANT — ALL THE PRECISION YOU'LL EVER NEED
BUT MY WORK INCLUDES THE MANUFACTURE OF—
I KNOW! AND YOU CANNOT POSSIBLY BUY A BETTER MACHINE FOR THE JOB THAN—
THE HAMILTON No. 1-B PRECISION SMALL GEAR HOBBING MACHINE
INVESTIGATE IT! YOU'LL SEE!
SPUR GEARS, WORM GEARS, and SPIRAL GEARS (up to 6" O.D.)
WORMS
SPECIAL TOOTH FORMS
GEAR SECTORS
PINIONS
and FACE GEARS
and BEVEL GEARS (up to 3" O.D.)
ASK for our gear hobber literature packet No. GH-740
2564
Hamilton
PRECISION SMALL-GEAR HOBBING MACHINE
THESE ARE REPRESENTATIVE USERS OF HAMILTON GEAR HOBBING EQUIPMENT
AiResearch Manufacturing Co. • Duncan Electric Co. • Bendix Aviation Corp. • Victor Adding Machine Co. • Lear, Co. • Minneapolis-Honeywell Regulator Co. • Geophysical Machine Works • Hughes Aircraft Co. • Westinghouse Electric Corp. • Rockwell Meters, Inc. • Borg Products Division • Herschede Hall Clock Co. • U. S. Navy Electronics Laboratory • Redstone Arsenal • Smallwood & Son Machine Co. • Link Aviation, Inc. • Bell Aircraft • General Mills • Elgin National Watch Co. • U. S. Naval Gun Factory • Grimes Manufacturing Co. • Texas Instruments, Inc. • McDonnell Aircraft Co. • American Machine & Metals • Stromberg-Carlson Co. • Hamilton Standard • U.S. Gauge Co. • Western Gear Works • Schlumberger Well Surveying Corp. • Douglas Aircraft.
THE HAMILTON TOOL COMPANY • 882 SOUTH NINTH STREET • HAMILTON, OHIO

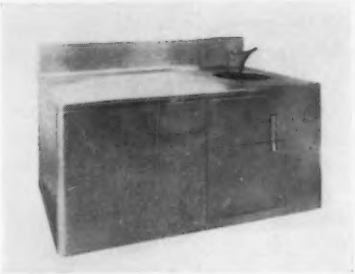
Circle 27 on Inquiry Card, page 81

CLEANING CENTER

Automatic bearing cleaning center features interchangeable heads with a capacity of one to eight bearings for each cycle. Automatic cycling permits thorough washing and drying with a single loading.

Other features: self contained fluid and air filters; may be used as filtration center for clean solvent supply; self contained compressed air heater for drying cycle; self contained hot oil de-preserving unit with spray rinse for pre-cleaning.

Machine was designed to de-preserve and clean all types and sizes of anti-friction bearings. Multi-spindle operation may be obtained with interchangeable washer heads to accommodate all sizes of bearings up to 14 in. diam. The wash and dry cycles are automatically controlled by a sequence timer.



Monarch Aircraft Sales, Inc.

Circle 65 on postcard for more data

SECONDARY PRESSURE STANDARD

Portable secondary standard type Q3401 for calibration and direct parameter measurement is now available. Interchangeable plug-in units, accommodating gage, differential, and absolute pressures, provide an overall accuracy of 0.05% for ranges up to 2500 psig, psid, or psia.

Standard can be rack mounted. Used with a remote pickup, it provides a single-channel FM system, since it incorporates a precision FM oscillator and an integral power supply. Two standards used together provide a versatile digital ratio measuring system, requiring the addition only of a dual heterodyne unit and a ratio counter.

Wiancko Engineering Co.

Circle 69 on postcard for more data

X-15 PAINT

made to resist +1200° F

The world's first rocket space ship, designed to carry man into the ionosphere, is painted with a Rinshed-Mason heat-resistant black enamel. This super tough finish was made expressly for North American Aviation, Los Angeles Division, manufacturers of the X-15. Aerodynamic temperature build-up to +1200°F. is expected as this "black phantom" reaches the re-entry phase into the earth's atmosphere at hypersonic speeds. The R-M enamel is expected to withstand these extreme temperatures and to dispel the absorbed heat at the fastest possible rate.

Your inquiry cordially invited.

R-M

RINSHED-MASON COMPANY

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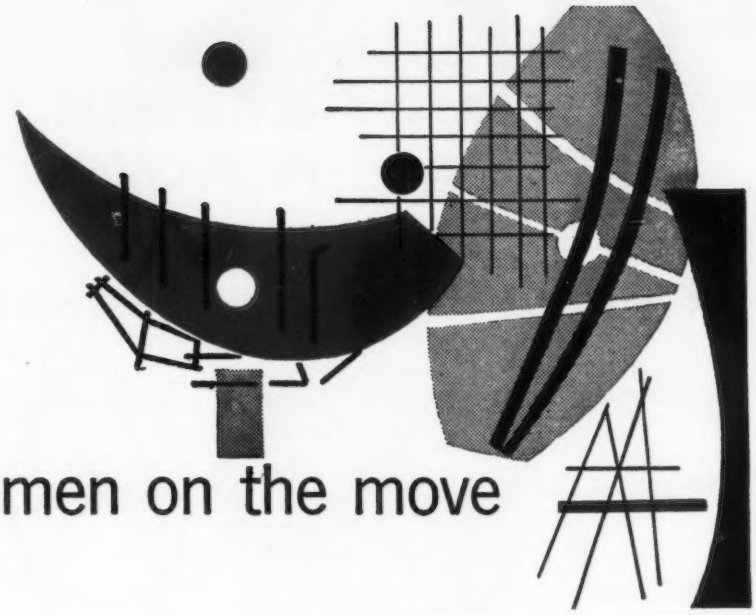
Anaheim, Calif.
Windsor, Ontario
Canada



men on the move

REAR ADM. EDDIE R. SANDERS, USN (Ret.) has joined the Ryan Aeronautical Company's Electronics Div. as executive advisor to the director of engineering and customer relations.

TOM COURTNEY, named program director for the Corvus missile system being developed by Temco Aircraft Corp.

M. CLAYTON BURGY, named technical specialist at the new rocket propellant plant of Hercules Powder Co. at Bacchus, Utah. ALEXANDER F. GIACCO, named manager of plans and programs for the Chemical Propulsion Div.

DR. CHARLES R. BURROWS, has accepted a position as vice-president and director of engineering of Radiation Inc.

CHARLES R. WOOD, JR., appointed manager, Defense Sales for the Special Products Div., Weatherhead Aviation and Missile Group.

ORLANDO J. MILLER has been named sales manager for Downer Aircraft Industries, Inc.

JACK F. ROACH, elected board chairman of Trans Electronics, Inc.

B. P. DUMARS, named assistant to the director; A. J. GRANT, sales manager, inertial navigation; W. G. FORT, sales manager, armament controls, and C. H. SWORD, sales manager, computers and controls at Autonetics, div. of North American Aviation. E. A. HOMES, named product manager industrial products.

FRIEDRICH L. VON DOBLHOFF has joined Vertol Aircraft Corp. as director of engineering-International Div.

LEO A. CROSSIN, appointed to the Western Div. customer relations staff of Goodyear Aircraft Corp.

ROBERT T. HARDING, appointed assistant chief engineer, product design department, Arma Div. American Bosch Arma Corp. VICTOR K. AUBREY, named site manager of the division's San Diego operation.

MOE BERLIN, named executive vice president; ARNOLD LOWELL, named treasurer of Arkwin Industries, Inc.

CHRIS G. FAHY, promoted to director of quality assurance at McCormick Selph Associates.

JACOB J. JAEGER, named executive vice president; HENRY J. FREDERICKS, named a vice president; EDWARD J. SHAGES, named vice president in charge of manufacturing; at Pratt & Whitney Co.

RICHARD P. GUNDLACH, named assistant secretary of Chromalloy Corp. WENDELL L. HAUBEIN comes to Propellex Chemical Div. as project engineer connected with a solid propellant gas generator contract.

LYMAN C. JOSEPHS III, has been promoted to the position of chief engineer at Chance Vought Aircraft Inc.

RICHARD E. ROBERTS, named to head the new organization of Instrumentation and Communications at General Electric's missile and Space Vehicle Dept.

CARLOS C. WOOD, named director of advanced engineering planning at Douglas Aircraft Co. CHARLES S. GLASGOW succeeds Wood as chief engineer, Long Beach div.

CHARLES SCHAEFER, appointed general sales manager of the Permanent Filter Corp.

DR. CLARE P. STANFORD named chief of the engineering department, Nuclear Div., Martin Co. DR. GEORGE D. SANDS joins Martin as director of scientific requirements. WILLIAM B. HARWOOD, appointed manager of information services for Martin-Cocoa at Cape Canaveral. FRED E. HAMLIN, named manager of information services for the Baltimore Div.

Jacob J. Jaeger
Pratt & Whitney

Richard P. Gundlach
Chromalloy

Lyman C. Josephs
Chance Vought

Richard E. Roberts
General Electric

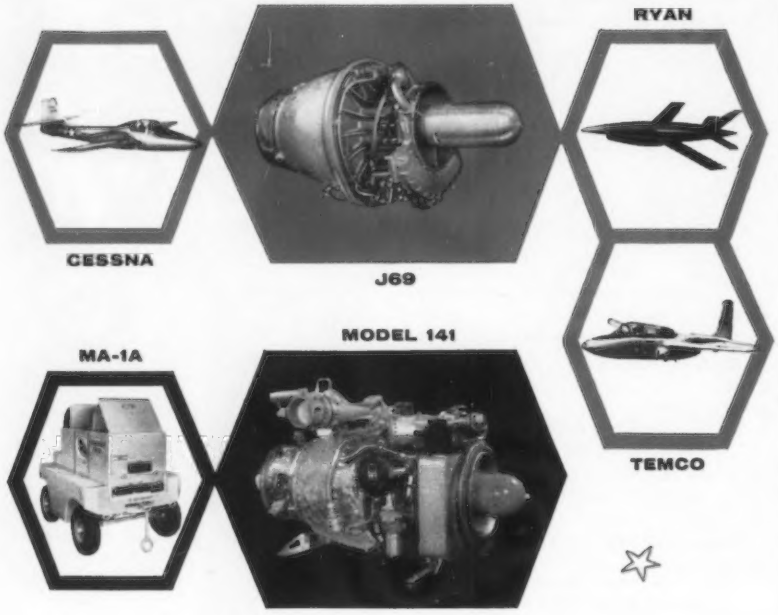
Charles Schaefer
Permanent Filter

Dr. George D. Sands
Martin

CAE

• RESEARCH
• DEVELOPMENT
• PRODUCTION

Building Tomorrow's Power



Continental Aviation & Engineering Corporation has more than 10 years' experience with small gas turbine engines.... Four versions of the J69 turbojet—delivering 920 to 1700 lbs. thrust—are in operation today. . . . The Model 141 turbine air compressor engine is widely used in jet aircraft ground support equipment. . . . Research and development programs are continuously in process on uprated turbines, new turbine configurations, solid fuel propellents, and solid fuel ramjet vehicles.

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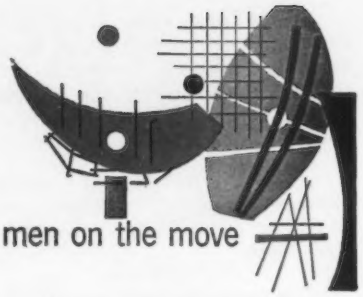
SUBSIDIARY OF CONTINENTAL MOTORS CORPORATION



TOM G. CONWAY appointed vice-president in charge of manufacturing of Pesco Products Div., Borg-Warner Corp.

A. R. SAID, elected executive vice president and a director of Gladding, McBean & Co.

JOHN W. LAZUR joined Hughes Aircraft Corp. as manager of military planning in the technical planning office.

William M. McCue
Steel Improvement & Forge Co.

Dr. Paul Webb
Firewel

WILLIAM M. MCCUE, has been advanced to manufacturing manager of the East 64th St. plant, Steel Improvement & Forge Co.

DR. PAUL WEBB, M.D., appointed consultant in aviation medicine, Aeronautical Div., the Firewel Co.

ROBERT T. STRINGER, named assistant sales manager, Aeronautical Div., The Firewel Co., Inc.

DR. STEVEN YURENKA, appointed manager of the Advanced Structures Research Laboratory, Research & Development Div., Narmco Industries, Inc. HAROLD H. LEVINE, named research chemist in the division.

Robert Stringer
Firewel

Dr. Steven Yurenka
Narmco Industries

Hot Water Boilers

8-page publication on hot water boiler design.

Orr & Sembower Inc.

Circle 76 on postcard for more data

Magnetic Amplifiers

New standard line of low level linear magnetic amplifiers described in Bulletin S-921.

Magnetic Amplifiers Inc.

Circle 75 on postcard for more data

Heat Resisting Alloy

Properties of "Dynaflex," an air-hardening specialty steel possessing high strength at elevated temperatures.

Latrobe Steel Co.

Circle 74 on posctard for more data

Maintenance and Repair

Booklet, "How to Make Your Own Machine and Repair Parts Quicker and Easier."

La Salle Steel Co.

Circle 96 on postcard for more data

Manometers

Brochure, "Manometers—Theory and Application."

Dynamics Corp.

Circle 97 on postcard for more data

Transducers Pamphlet

Firm's pressure transducers for aircraft described.

Aeronautical Div.
Minneapolis-Honeywell Regulator Co.

Circle 125 on postcard for more data

Transformer Catalog

24-page catalog on pulse transformers.

PCA Electronics Inc.

Circle 79 on postcard for more data

Facilities

Brochure covers all phases of firm's forging facilities and range of products.

Park Drop Forge Co.

Circle 84 on postcard for more data

Jigs and Fixtures

Catalog on basic fixtures includes 70 full size tracing templets.

Standard Parts Co.

Circle 94 on postcard for more data

Pressure Switches

Brochure, "Selection and Applications of Pressure Switches," explains factors which govern selection of the most economical type of switch.

Gorn Electric Co.

Circle 119 on postcard for more data

Facilities

Brochure shows facilities, operation of precision machining firm.

Western Design
Div. of U. S. Industries

Circle 83 on postcard for more data

Selenium Rectifiers

Full particulars on vacuum process selenium rectifiers.

Syntron Co.

Circle 109 on postcard for more data

Catalog

Complete information on firm's temperature probes, pressure transducers, and pitot-static tubes.

Rosemount Engineering Co.

Circle 78 on postcard for more data

Jig Borer

Brochure on numerical control No. 4EA precision jig borer.

Pratt & Whitney Co., Inc.

Circle 77 on postcard for more data

Temperature-Millivolt Tables

Chart of temperature-millivolt conversion tables for thermocouples.

Thermo Electric Co., Inc.

Circle 120 on postcard for more data

Frequency Sensor

Bulletin 400 FS shows line of frequency sensors for use in automatic instrumentation of frequency for aircraft, missiles, ground control installations, telemetering equipment, and industrial control equipment.

Magnetic Circuit Elements, Inc.

Circle 110 on postcard for more data

Automatic Programming

Bulletin describes POGO automatic programming system for firm's digital computer.

Bendix Computer Div.
Bendix Aviation Corp.

Circle 107 on postcard for more data

Cable Systematics

Four-page illustrated booklet entitled "This is Cable Systematics."

Aeronautical & Inst. Div.
Robertshaw-Fulton Controls Co.

Circle 115 on postcard for more data

Thermo-research

Brochure explains firm's new Thermo-Research Center.

Chandler-Evans Corp.

Circle 123 on postcard for more data

Flotation Systems

Brochure describes flotation units employed in metal working operations.

U. S. Hoffman Machinery Corp.

Circle 116 on postcard for more data

Temp Transducers

Illustrated 10-page catalog shows line of temperature transducers.

Rosemount Engineering Co.

Circle 125 on postcard for more data

Welders

Precision stored-energy welders described, welding discussed.

Weldmatic Div.
Unitek Corp.

Circle 126 on postcard for more data

Testing Damping Materials

Two "Technical Review" articles available; describing techniques, theory for measuring damping effect of surface coating material for reducing noise and vibration.

B & K Instruments Inc.

Circle 121 on postcard for more data

jamesbury

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¾" Jamesbury High Pressure Valve in use at Goodyear Tire & Rubber Company, Akron, Ohio, on 3,000 P.S.I. Water Service at Ambient Temperature.

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Instrumentation

The Western Industries edition of publication, "Modern Precision," contains round-up of instrumentation applications in the far Western States.

Leeds & Northrup Co.
Circle 93 on postcard for more data

Screw Threads

Digest entitled "Unified and American National Screw Thread Data" forms a new issue of H & G Die Headlines.

Eastern Machine Screw Corp.
Circle 124 on postcard for more data

Open-Type Motors

Open-type motors suitable for many applications previously requiring enclosed designs are described in bulletin 05-51B9040.

Allis-Chalmers Mfg. Co.
Circle 100 on postcard for more data

"60" Ampere System

40-page bulletin (No. 60) describes "60" ampere steel-enclosed trolley busway electrification system.

Feedrail Corp.
Circle 118 on postcard for more data

Servo Mechanism

Literature on electromechanical subminiature servo mechanism model 20-200.

Servo Development Corp.
Circle 98 on postcard for more data

Propane Diluter

Bulletin PD-1 presents "package units" mixing propane or butane with air to supply standby fuel and maintain heating and refrigeration.

Selas Corp. of America
Circle 81 on postcard for more data

Valve Flanges

Bulletin F 8517 illustrates many flanges used on air valves.

Barber Colman Co.
Circle 91 on postcard for more data

Gear Pumps

Bulletin describes series 700 pump which has capacities up to 3 GPM.

Eco Engr. Co.
Circle 108 on postcard for more data

Thin Film Optics
Outline of firm's activities.
Spectracoat Inc.
Circle 101 on postcard for more data

Silicones
Brochure on uses of silicones.
Dow Corning Corp.
Circle 113 on postcard for more data

Rocket Fuel Control
Brochure on testing for rocket fuel systems.
Systems Div.
Consolidated Electrodynamics
Circle 92 on postcard for more data

Connectors
Descriptions of right angle pin and socket, test point connectors.
DeJur-Amsco Corp.
Circle 80 on postcard for more data

Navcom Module
Brochure on navigation module Model 2374 for Vor/Loc and marker beacon.
Lear Inc.
Circle 99 on postcard for more data

Component Production
Facilities for producing forged and stamped parts for missile and rocket applications described in a six-page folder entitled, "Countdown Coordination."
Transue & Williams
Circle 106 on postcard for more data

Facilities
Activities, facilities, described.
Sanders Associates Inc.
Circle 87 on postcard for more data

X-Ray Film Handbook
32-page illustrated handbook on industrial X-ray films.
The Gevaert Co. of America
Circle 127 on postcard for more data

Facilities Brochure
Description of company's four factories in USA and five foreign divisions.
Pfaudler Permutit Inc.
Circle 85 on postcard for more data

Magnetic Plugs
Specifications, general information on line of more than 500 types of magnetic plugs.
Lisle Corp.
Circle 104 on postcard for more data

Facilities
Folder gives production picture.
Fenn Mfg. Co.
Circle 86 on postcard for more data

Specification Sheets
Line of temperature Indicators, Controllers and Transmitters featuring corrosion-proof fiber glass cases and suitable for temperatures ranging from —400 to +1000F is described.
Fischer & Porter Co.
Circle 112 on postcard for more data

Word Indicator Lights
Sixteen pages on word indicator lights.
Master Specialties Co.
Circle 95 on postcard for more data

Frebank Facilities
Data book on facilities, products of pressure switch producer.
Frebank Co.
Circle 88 on postcard for more data

Fueling Systems
Thirty page publication on aircraft ground pressure fueling systems.
Fuel Div.,
Parker Aircraft Co.
Circle 117 on postcard for more data

Printed Circuit Drilling
Brochure describes printed circuit method.
Zagar Inc.
Circle 82 on postcard for more data

Jet Engine Overhaul
Pictorial engineering report on overhaul and repair of jet engines and airframes.
Sciaky Bros., Inc.
Circle 102 on postcard for more data

Auxiliary Power Unit
Publication GET-2798, 8 pages, describes features and characteristics of firm's 40 hp turbodrive.
General Electric Co.
Circle 105 on postcard for more data

Dial Thermometers
Twelve page catalog 205 on "Dial Thermometers."
U. S. Gauge
Div. of American Machine and Metals Inc.
Circle 122 on postcard for more data

Testing Facilities
Bulletin 5801 describes complete line of laboratory and field testing facilities and services.
U. S. Testing Co., Inc.
Circle 89 on postcard for more data

Stock List
Expanded tool steel stock list, No. 13, is available with engineering data, selection guide.
Uddeholm Co. of America, Inc.
Circle 114 on postcard for more data

Power Filing
Power filing machine designed for filing, trimming and deburring a wide variety of small components is described in bulletin.
Newage Industries, Inc.
Circle 90 on postcard for more data

Automatic Set-Screw Driver
A new automatic set-screw driving device called Setomatic, is reviewed in a new four-page bulletin.
Standard Pressed Steel Co.
Circle 111 on postcard for more data

STRUCTURAL TEST ENGINEERS

NAA has immediate openings for senior engineers to work on such top-level projects as the B-70, F-108 and the rocket ship X-15.

As part of our expanding organization, you'll manage elevated temperature test projects, including planning and design; conduct tests and report results.

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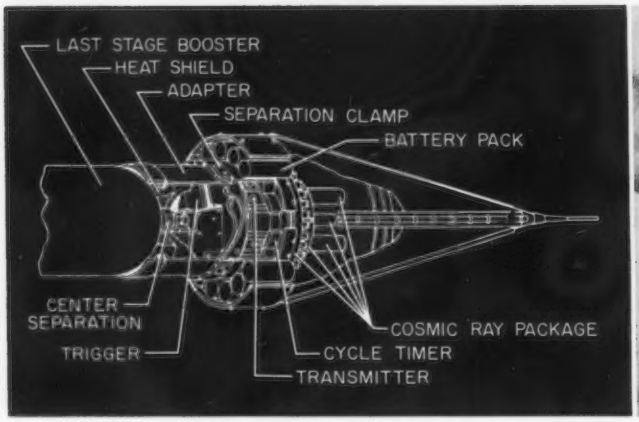
If you know instrumentation and equipment limitations, and are experienced in the design of setups, there is a career for you measuring strains, static and dynamic loads, temperatures and deflections.

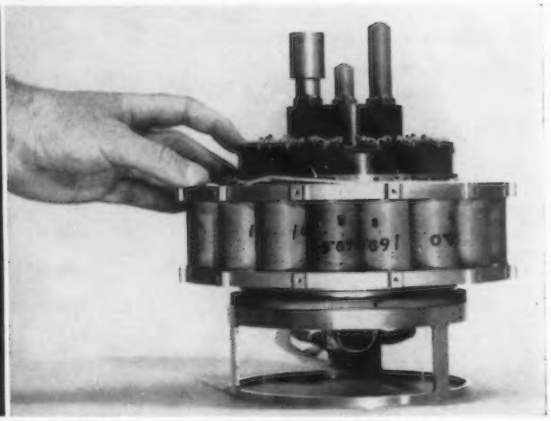
Write to: Mr. L. D. Stevenson, Engineering Personnel, North American Aviation, Inc., Los Angeles 45, California.

THE LOS ANGELES DIVISION OF
NORTH AMERICAN AVIATION, INC.

industry notes

PIONEER IV: TECHNICAL DREAM COME TRUE





Cutaway view of Pioneer IV's 14 lb payload and picture of instrumentation. Two larger tubes at top of picture measured radiation; smaller one between is voltage regulator. Radio transmitter surrounded by outer ring of batteries took up about half of payload weight. Photoelectric sensor was at bottom.

Performing substantially as planned, Pioneer IV is moving in an elliptical orbit around the sun.

What did it:

Carrier rocket called Juno II used modified Jupiter (developed and built by the Army Ballistic Missile Agency) as first stage. Fashioned from aluminum alloy rolled from flat sheets, this booster used high grade kerosene as fuel, liquid oxygen oxidizer.

Single-chambered gimballed Rocketdyne engine producing 150,000 lb thrust raised the 60 ton probe vehicle to about 10,000 mph.

After booster was jettisoned, three stage upper assembly of 15 solid propellant rockets raised the Army-NASA vehicle to neighborhood of 24,800 mph. This part of Juno II was furnished by the Jet Propulsion Laboratory. Second stage was 721 lb hollow cylinder with 11 Sergeants. The 207 lb third stage, three Sergeants in triangular fashion, sat in the center of the ring formed by the second stage motors. After second stage burnout, third stage ignited and pulled out of its case.

Fourth stage, single 59 lb rocket motor, gave the payload its final increment of speed before gradual deceleration began. A small explosive charge and spring pushed the payload away after burnout.

What it did:

The 23-inch-long 14 lb gold-plated fiberglass payload was spinning (for stabilization) ever since a spin-launcher inside Juno's nose section, just ahead of the modified Jupiter, started whirling on blast off. (The rotating aluminum spin-launcher was fabricated to hair-splitting tolerances by the Reynolds Metals Co. in Sheffield, Ala.) Small wire-like arms extended perpendicularly from the

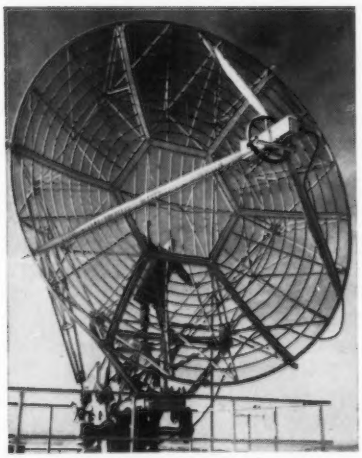
payload when it entered the cislunar area. Spin momentum transferred to these arms to reduce rotational speed.

Had Pioneer IV come within 20,000 miles of the moon instead of its path of 35,000 miles away, reflected light from the moon might have triggered a twin-apertured photoelectric sensor. Sensor of this type could trigger a camera in future probes. Above the sensor in the payload, 1.1 lb transmitter, powered by mercury batteries, sent tracking signals on a new space probe range of 960.05 megacycles.

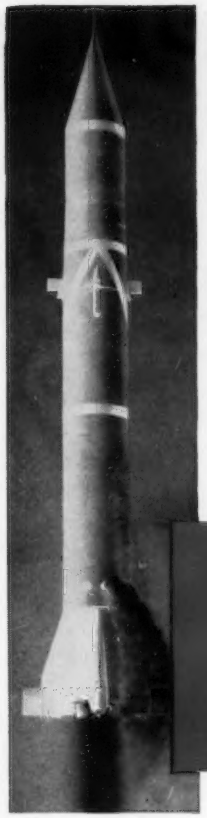
Inside the conical hood, cosmic ray package measured intensity and energy level of radiation in space. Package consisted of two Geiger - Mueller tubes and a voltage supply line. Four mm of lead shielding in one of the tubes provided the only change over the Pioneer III payload which went 63,000 miles high.

Gold-plated (for conductivity and radio antenna purposes), Pioneer IV became a planet in yearlong elliptical orbit round the sun.

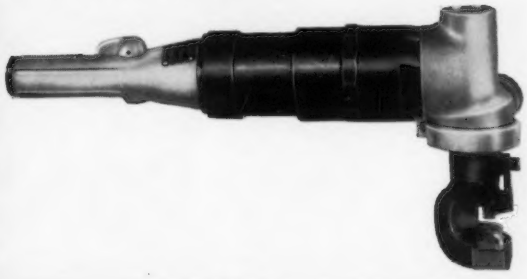
ANTENNA TRACKED PROBE



Last signals from Pioneer IV were picked up by new 18 ft parabolic antenna at General Electric's General Engineering Laboratory tracking station, Schenectady, N. Y. Probe tested communications systems as well as radiation.



Here's a tool that cuts metals, plastics *and costs!!!*



BUCKEYE portable NIBBLER

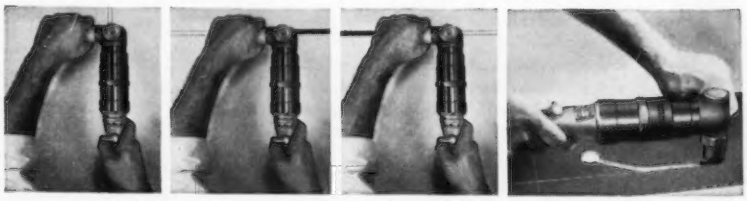
AIR...or ELECTRIC

U. S. ARMY PHOTO

Eats right through 8 gauge mild steel at a 5-6 foot-per-minute rate. Makes a sharp, clean cut, free of distortion on sides, top and bottom. Works on materials of any size or shape. Starts cutting anywhere on the work, follows any contour, in any direction.

Now — bring the tool to the work, eliminate handling time and costs on large, cumbersome workpieces. Now — use this economical, portable tool for cutting metals and plastics, keep expensive, stationary machinery available for regular work.

Pick your type of power — air or electric — from ten models of the Buckeye nibbler, one designed for your kind of work.



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Our engineers learned long ago, while perfecting their own critical aircraft parts cleaning operations, that building a good ultrasonic cleaner is a precision job that calls for the best in design thinking.

As a result, Curtiss-Wright has developed ultrasonic cleaning equipment with performance features not only important to production, but absolutely essential to the critical cleanliness demands of missile components:

- **Uniform cleaning action—no dead areas**
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Whether you want to clean small or large parts, sub-assemblies or complete assemblies—whether you have a cleaning problem where speed and economic factors are important or wherein extreme cleanliness is the prime consideration, our engineers have the knowledge and experience to supply the equipment you need.

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PRINCETON DIVISION
CURTISS-WRIGHT
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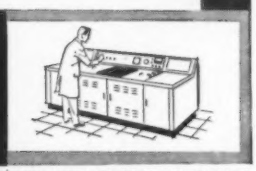

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industry notes

TERRA-SCOPE

Kaman Aircraft may produce some future commercial and military Rotodynes if anticipated U. S. orders materialize. All Rotodyne manufacturing has been done by the Fairey Aviation Co., Ltd., for which Kaman is U. S. representative. New York Airways is buying five to 15 of the vertical take-off airliners.

NASA announced that government researchers are about ready to start advanced testing of an ionic propulsion motor for missiles. Program is moving ahead steadily though actual development is still years away.

Sidewinder missiles have been ordered for the current generation of Swedish fighters including the Saab-35 Draken.

Bendix Aviation Corp. is developing a special analyzer that will monitor temperature and vibration conditions on jet engines. Customer: British Overseas Airways Corp. New self-contained long range navigation system for jet and turboprop airliners, based on the Doppler radar principle, has been flight-tested successfully, according to Bendix's Radio Division.

Defense Dept. says "it is anticipated" that substantial quantities of Chance Vought's F8U-2N Crusader will be produced for Navy carriers beginning in early 1959.

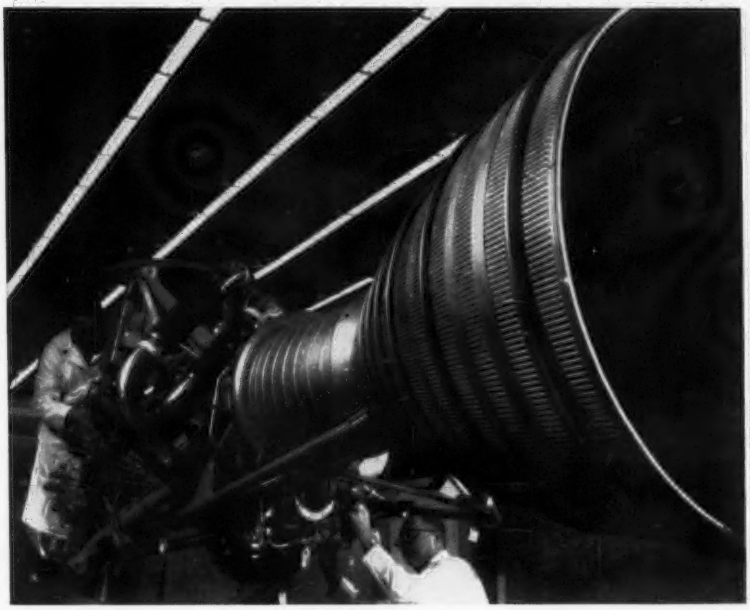
The Mace replaces the Matador at the Air Force's 587th Tactical Missile Group in Germany this Spring.

Molded mica capacitor produced by General Instrument Corp., is called 73 per cent smaller (.0077 cubic inch) and 69 per cent lighter (½ gm) than nearest comparable units.

Measurements of gravity by Air Force Cambridge Research Center using a gravity meter installed in a KC-135 Stratotanker are being hailed as steps towards learning the true shape of the earth, exact position of the center of earth.

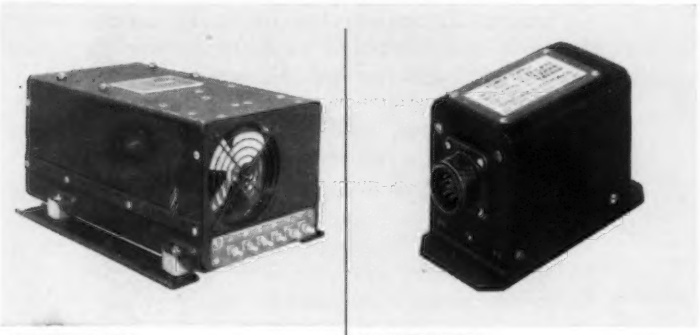
The Ryan Vertiplane research aircraft is entering transition phase of testing. The plane has successfully completed first "Conventional" flight tests with its double wing flaps retracted.

World's largest fiberglass radome, 68 ft. in diam. and over seven stories high, has been produced at Goodyear Aircraft for General Electric's Heavy Military Electronics Dept. under Air Force contract.



BOOSTER FOR SPACE-PROBES

Mechanics at Rocketdyne's Canoga Park, Calif., plant make adjustments on main booster engine of the type used as first stage in Pioneer IV and Discoverer I. First stage propulsion system also includes 1,000-lb-thrust twin vernier engines. It produces about 150,000 pounds of thrust.

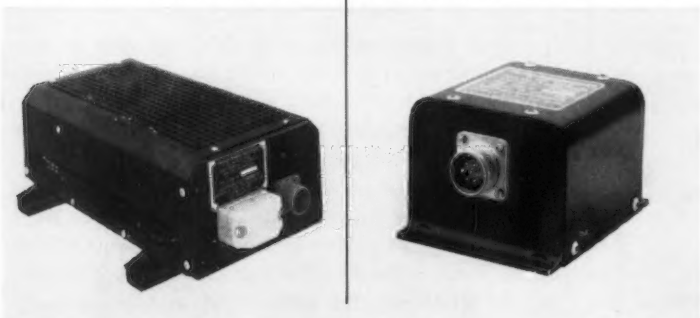


SELENIUM TR UNIT
shock mounted model 28V100-5

SILICON TR UNIT
convection cooled model 28VS100C

DC-DC CONVERTER
dual output model 75D2D50

STATIC DC-AC INVERTER
high temperature effiency, model 283I50



Why Chatham supplies more aircraft power conversion units than anyone else!

Preference of aircraft designers has made Chatham the world's number one supplier of power conversion equipment for missiles . . . jets . . . airliners. Here's why Chatham holds this position.

Custom manufacture: Chatham tailors each unit to supply top performance under all environmental conditions with minimum size and weight.

Components control: All solid-state components are made right at the Chatham plant. Thus, Chatham power supplies are never limited by "specs" of commercially available components.

AC-DC, DC-DC, DC-AC, silicon, germanium, selenium: Any requirement met. Many Chatham units are immediately available. To meet extraordinary demands, Chatham will design and produce an original unit to any specifications you outline without delay.

When specifying power conversion equipment, think of Chatham first because Chatham is first. For specific data, contact: Chatham Electronics, Division of Tung-Sol Electric Inc., Livingston, New Jersey. Sales Offices: Culver City, Cal., Dallas, Tex.

CHATHAM ELECTRONICS
division of
TUNG-SOL ELECTRIC INC.

CHATHAM—WORLD'S LEADING SUPPLIER OF AIRBORNE CONVERSION EQUIPMENT

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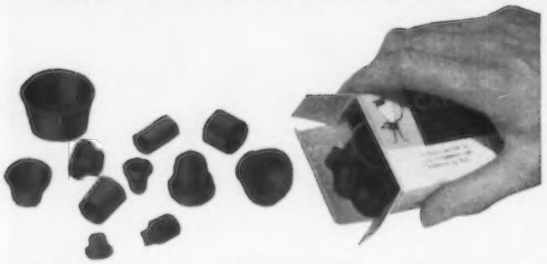
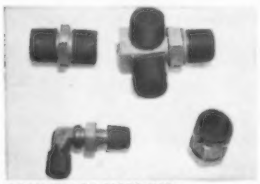


will give you dozens of ideas for protecting products like these

JUST PUSH THEM IN . . . OR PUSH THEM ON
Tapered (non-threaded) CaPlugs can be used as caps or plugs, inside or outside of threaded or plain fittings. Made of tough, flexible Polyethylene, CaPlugs are unaffected by most chemicals, acids and solvents . . . will not collapse, chip, break or shred.

"KID GLOVE" PROTECTION WITH A DUAL PURPOSE
Here's how Resistoflex Corp. uses CaPlugs "to protect critical threads and machined surfaces and to keep the interiors of hose assemblies clean." Says Resistoflex, "CaPlugs prove most effective for both functions as well as being particularly easy to install."



COUNTLESS USES BY THOUSANDS OF USERS
Bell Aircraft Corp. applies both threaded and non-threaded CaPlugs to a wide variety of parts (such as these) in the manufacture of guided missiles, electronic components, rocket engines and servomechanisms. With numerous styles stocked in over 500 sizes, CaPlugs are readily available to answer practically every closure need.

MAKES A PRODUCT LOOK ITS "SUNDAY BEST"
On this Alemite Accumatic Valve, colorful red CaPlugs add snappy eye appeal and indicate care of manufacture. Says Stewart-Warner Corp., "CaPlugs help impress the customer with the steps that have been taken to protect the equipment and convince him of the continuing need for protecting lubricants against contamination."

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RUSH free assortment of CaPlugs, literature and prices to us.

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COORDINATING A COUNTDOWN

Often overlooked in missile publicity, countdown-monitoring systems are big achievements of U. S. technology.

Countdowns of Titan are programmed in advance and monitored by a system specially developed by Martin's Denver Div., which is responsible for design, fabrication, and testing of the missile.

Here's how the electronic masterpiece — known as Master Operations Control (MOC) — works:

As in other countdown systems, checks of vital functions are programmed well ahead of actual test. Four rack "Master Sequencer" follows this program for up to 200 functions in the countdown.

When the sequencer sends signals for some function such as pressurization, this shows on the test conductor's console. Green lights indicate the function has been completed and checked. A red light shows when an automatic "hold fire" is imposed. Number of the system and the number of the item in the system in which the malfunction occurs is then shown on the console.

Console shows how much time is available on certain limited life items. In certain situations, test conductor can decide to override a hold automatically imposed. He can also reset the entire sequence for another countdown. And as in other systems, time of countdown in seconds is shown on his console.

On test firings at Cape Canaveral, hold fire or engine shutdown can be called by test conductor, MOC operator, range safety officer, flight safety officer, or pad control officer. The latter three carry kill switches for this purpose.

Besides conductor's console and master sequencer, MOC consists of:

- Erector console showing position of various erector mechanisms, and including switches to operate various erector mechanisms.
- Water system console showing how programmed water system functions—such as spraying of thrust chambers after firing—are going, and including manual controls for emergency measures.
- Umbilical control console, where lights show whether disconnects are attached. Here switches operate the hydraulic cylinders which retract the umbilical tower booms.

MOC can also make a precountdown check of any subsystem or system of subsystems to verify performance in advance.

F-94 NOSE

Frangible nose is produced for F-94 "Starfire" on press-mounted matched mold at Lockheed Aircraft Corp., Burbank, Calif. Material is polyester resin reinforced with chopped glass fibers. This is an example of high tool cost to give low fabrication costs.

"RAMJET TRANSPORTS FEASIBLE"— MARQUARDT

Ramjet-powered supersonic air transports are now feasible, according to Roy E. Marquardt, president of Marquardt Aircraft Co.

Marquardt said recent ground and flight tests have shown ramjet speed and altitude capabilities as well as fuel economies suggesting "an ideal cruise propulsion system for supersonic transports."

Propulsion system would include afterburning turbojets for comfortable takeoff and initial acceleration. Ramjets, taking over at about Mach 2 and 30,000 ft., would provide climb and acceleration to an ideal cruise regime of Mach 4 and 80,000 ft.

Pointing out that a recent ground test subjected a ramjet to simulated flight conditions of 14 mi above the earth at record speeds for an air-breathing engine, Marquardt added:

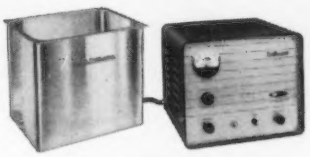
"The practicality or need for supersonic air transports needs to be firmly established before any accurate prediction can be made with regard to when such transports would be in operation. The fact is that we know we could if we wanted to today."

MAMMOTH narda SONBLASTER

America's first mass-produced industrial-size ultrasonic cleaner!

SAVE *7 ways over costly solvent, alkaline or vapor degreasing:*

• Clean faster, speed production! • Cut rejects, eliminate bottlenecks! • Save on chemicals & solvents! • Eliminate expensive installation! • Cut maintenance and downtime! • Save on floor space! • Release labor for other work!



G-1501 generator, NT-1505 tank.

MAMMOTH 5-GALLON TANK $695

Other models from $175. 2-year guarantee on all units.

SPECIFICATIONS

Interior Tank size (in.), 10W x 14L x 9½H. Tank Capacity, 5 gallons.

Submersible Transducers

Model NT-604 — Hermetically sealed heli-arc welded stainless steel case. Radiating face: 27 sq. in. Effective plane of radiation: 40 to 50 sq. in. (approx. 10" x 5"). Effective cavitation of volumes: up to 1200 cu. in. at 24" tank height (5 gal.) and 2400 cu. in. at 48" tank height (10 gal.). Swagelok tube fitting on side or end for internal tank wiring.

Model NT-605 — Same as NT-604 except for bulkhead fitting on back for external wiring. Eliminates electrical conduits in solutions.

Now you can say goodbye to expensive chemicals, solvents, and degreasing equipment . . . reclaim valuable floor space . . . eliminate high installation costs . . . just by installing a Narda Series 1500 SonBlaster. At the same time, you'll get better, faster cleaning, and you'll need fewer people to do the job!

Get the tremendous activity of the new 200-watt Narda SonBlaster, with the largest transducerized tank ever made, at the lowest price in the industry! Choose from transducerized tanks or submersible transducers for use in any arrangement in any shape tank you desire. Up to 4 submersible transducers can be easily operated from the same generator at one time; load selector switch provided — an exclusive Narda feature.

Simply plug the SonBlaster into any 110-115 V AC line, and flip the switch. In seconds, you'll clean 'most any mechanical, optical, electrical, medical or horological part or assembly you can think of. Perfect, too, for brightening, polishing, radioactive decontaminating, pickling, quenching and plating; emulsifying, mixing, sterilizing, impregnating, degassing, and other chemical process applications.

Mail the coupon for free help in determining the model that's best for you.

The SonBlaster catalog line of ultrasonic cleaning equipment ranges from 35 watts to 2.5 KW, and includes transducerized tanks as well as immersible transducers. If ultrasonics can be applied to help improve your process, Narda will recommend the finest, most dependable equipment available — and at the lowest price in the industry!

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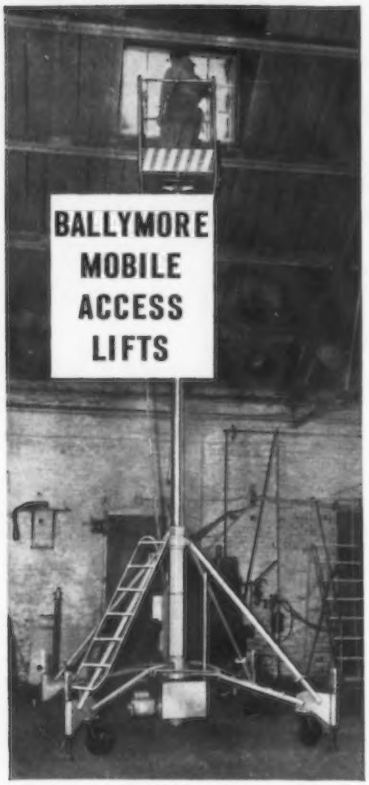
NEW METHODS FOR REACHING HIGH PLACES SAFELY...



For working easily and safely at levels up to 40 feet above the floor, there's nothing like Ballymore Mobile Access Lifts. These power platform lifts are readily portable and, by using levelizing jacks, maintain a steady, firm position at any location. When folded, the lifts pass through narrow openings, into and out of elevators.

A push-button switch on the guardrail gives the user complete control of the lift. Used indoors and out for an almost endless variety of jobs. Six different models available for maximum reaches of 19 to 42 feet.

Write today for complete information to the Ballymore Company, West Chester 27, Pa.

HYDRAULIC LIFT WORK PLATFORM

Another Safety Product by Ballymore. Designed for safe use at levels between 7 and 20 feet. Can accommodate up to 3 men. Portable, flexible, safe. Write for details.

LOOK FOR THIS LABEL TO BE SURE IT'S THE BEST!

BALLYMORE COMPANY WEST CHESTER, PA.

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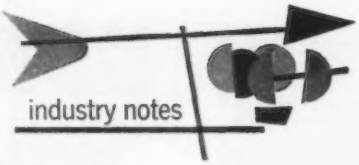

FACILITIES . . .

Acquisition of Aircraft Radio Corp., Boonton, N. J., by Cessna Aircraft Co. marks latter's entry into electronics field.

The Eastern facilities of Aerojet-General Corp. at Frederick, Md., formerly known as Aerojet's Ordnance Engineering Div., are now designated the Atlantic Div.

A 27,000 sq ft addition to facilities of the Hydraulic Research and Manufacturing Co., (Bell Aircraft subsidiary) at Burbank, Calif, is slated for completion this Spring.

Monogram Precision Industries, Inc., Culver City, Calif., has acquired Lamatic Co., North Hollywood fabricator of exotic metals for high speed craft, from Angelus Industries Inc.

New $1,000,000 hydraulic research and manufacturing facility is in operation at Chance Vought Aircraft, Dallas.

Republic Aviation Corp. has opened an office near International Airport, Los Angeles, for closer contact with offices on West Coast.

"Weapon Systems" Div. established by Aeronca Manufacturing Corp. will organize and supervise firm's industrial team projects.

Los Angeles Div. of North American Aviation will be expanded 113,000 sq ft by El Segundo Laboratories, to be in operation by July. These R & D facilities will test manned aircraft designed for triple-sonic speeds.

Atlantic Research Corp. is beginning full occupancy of its new $1,000,000 headquarters near Washington, D. C.

Boeing Aircraft plans to have its eighth wind tunnel in operation by the end of the year. Arc discharge tunnel will have a 40-inch test section, increasing testing capabilities to Mach 10 to 27 range.

Martin's Baltimore Div. has replaced its single engineering division with two new organizations—Manned Vehicles and Missiles-Electronics.

AIRETOOL pneumatic production tools pay for themselves in higher production per man-hour. When the going gets rough, high-torque AIRETOOL air motors don't lose power, stall . . . as others do. Work goes faster . . . costs less. Get full details about AIRETOOL'S complete line — horizontal and vertical grinders, sanders, drills, and screwdrivers. Write for Bulletin No. 67.

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INDUSTRIAL GIANT

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HAS **2,400 MANUFACTURING CONCERNS**

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Dade County Development Department

Section 71

Chamber of Commerce Building

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An agency of the Metropolitan Miami government

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Chandler-Evans Corp. has opened a new Thermo-Research Center, designed to test sensitive fuel control mechanisms under searing heat similar to that generated by friction in supersonic flight.

Flight Propulsion Div. is new name for General Electric's aircraft gas turbine organization.

National Research Corp. has formed a Metals Division to consolidate production and marketing of high purity tantalum, its alloys and other rare metals and related chemicals.

Construction of a high-flow installation for water-testing of rocket engine components, was started this week at Rocketdyne's Canoga Park plant.

Topp Industries, Inc. announced the formation of U. S. Science Corp. as a wholly-owned subsidiary which will acquire operations of Topp Manufacturing Co.

Aerojet-General Corp. has established an Anti-Submarine Warfare Division to speed development and production of a new type anti-submarine torpedo, and to expand ASW basic research.

Western Gear Corp's Precision Products Div. is constructing a new Reliability and Quality Assurance Building at Lynwood, Calif. Completion: this summer.

The Midwest's largest cold roll-forming mill is being installed in the Franklin Park plant of Woodside Engineering Co.

Convair Instruments, a facility of Convair Div. of General Dynamics Corp. has moved into new and larger quarters at 3595 Frontier St., San Diego.

Unholtz-Dickie Corp., first organization solely for professional engineering services of vibration problems, was formed in Hamden, Conn., by four executive engineers of M B Manufacturing Co.

Temco Aircraft's engineering staff is expanding into a new 52,500 square foot Engineering Center addition.

Mallory-Sharon Metals Corp. announced a reorganization of its research and development team, concomitant with its entry into the refining and production of such special metals as zirconium and hafnium.

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Precisely Regulated for Missile Testing and General Use

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SILICON POWER SUPPLIES

available in 30 standardized and militarized models from 30 to 1500 amps... 6 to 135 volts. CHRISTIE'S QUALITY CONTROL is approved by the A.E.C., leading aircraft and missile manufacturers.

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CHRISTIE ELECTRIC CORP.

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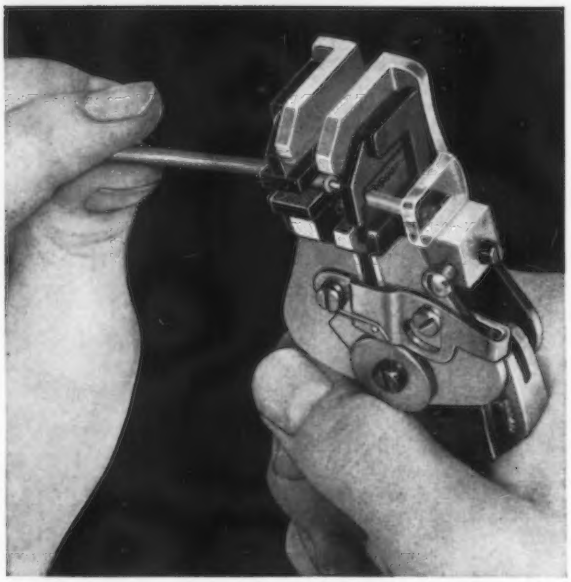

Just One Squeeze with IDEAL's New "Custom Stripmaster" Removes Teflon* and Other Hard-to-Strip Insulations

To help prevent wire nicking and insulation damage, these new IDEAL "Custom Stripmasters" are precision drilled on watchmaker's equipment.

With Ideal's new Custom Stripmasters, a light squeeze on the handles strips any wire completely clean and bare up to a full 7/8 inch.

To help prevent nicking and scraping of wires, the Custom Stripmaster's matched sets of blades are precision drilled on watchmaker's equipment to the exact wire sizes. Counterbored blades ride on cut insulation to prevent scratching of stripped wire. Jaws grip wire firmly to prevent insulation damage. 3 models available. Wire sizes from No. 10 to 30.

*Reg. Trademark of DUPONT

Custom Stripmaster® Patented, No. 2,523,936 by IDEAL

IDEAL INDUSTRIES, Inc.
1390-D Park Avenue, Sycamore, Ill.

Gentlemen: Please send catalog information on IDEAL's New "Custom Stripmaster."

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Company_____

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CONTRACTS

Important aircraft and missile contracts are part of the industry's humming pace thus far in 1959.

Thiokol Chemical Corp. became the first firm to receive a definitized contract for a subsystem in the Air Force's Minuteman program. The $77-million contract calls for research and development of three stages of Minuteman's solid propellant propulsion system, most of the work taking place at Brigham City, Utah. Thiokol also recently received a $2,383,173 Army contract for R and D on improved solid propellant rocket motors of the XM33 type used in the Polaris first stage.

Rocketdyne received a $25-million fixed-price-incentive contract from the Air Force for Thor IRBM engines. The contract marks a departure from the traditional associate prime contractor method of Air Force buying. System rewards contractors for exceptional performance, penalizes them for unsatisfactory performance.

Chrysler received an $8,362,732 Army contract for its Chrysler program.

A subcontract of $6,700,000 to Lear Inc. from Bell Telephone was for research and development on Nike Zeus. This reflected the picture drawn to the House Space Committee, i.e.; work will be limited to research and development; no production set for the 1960 fiscal year.

The missile picture was also affected by: $50,731,000 Army contract to Raytheon Mfg. Co. for Hawk Missile System; $1-million Army contract to Rocketdyne Div., North American Aviation, for rocket engines for ABMA's clustering project; $8-million Air Force contract to Lockheed Missile Systems Div. for continued testing of research vehicles in support of Bomarc; first significant production contract resulting from U. S.-Canada talks last year. Latter contract, between Boeing Airplane Co. and Canadair Ltd., calls for Canadair's producing wings and ailerons for Bomarc.

Recent developments in aircraft manufacturing:

- The Navy announced a $28.4-million follow-on production contract with Grumman Aircraft Engineering Corp. for WF-2 Tracer early warning aircraft.
- New Navy contracts totaling $8-million to Lockheed Aircraft for development and testing of Electra transport as tactical test bed for antisubmarine warfare systems in production airplanes.
- Martin Co. received a $23-million contract for production of P5M-2 Marlins.

INDUSTRY TRACKING CONGRESSIONAL MOVES

Some of the aircraft-missile industry affairs facing the 86th Congress this year:

- Extension of the Renegotiation Act — due to expire June 30. One issue: has the industry been tagged excessively with excess profits taxes despite an earning rate which is less than half that of comparable manufacturing enterprises?
- Disparity in patent provisions. The act creating NASA says that almost all inventions made under NASA contract belongs exclusively to the Government. Defense department regulations allow the company to retain title, the government holding license rights.
- Indemnification of contractors covering a greater area of risk in missile and other weapon programs. Amendments on the Procurement Act to erase flaws.

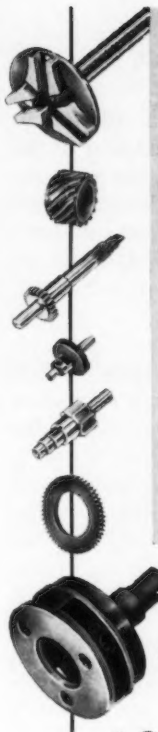
880 INSTRUMENTATION

The Convair 880 jet airliner contains a unique electrical system designed and built by General Electric, which also produced 113 other products for the plane.

The 880 uses an automatic parallel a-c system with four generators, each located in an engine nacelle. Generators are driven by GE constant speed drives mounted on the aft side of the engine's forward gearbox. Transmission between engine and generator provides constant generator speed.

WHY JUNO II?

The Reader's Encyclopedia informs us that the original Juno was a matronly goddess in Roman mythology. Since she was the wife of Jupiter, she was the queen of heaven.



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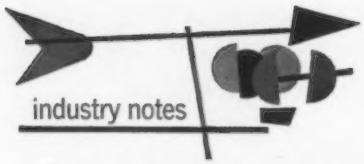

. . . TECHNICAL

Liquid for aircraft and missile gyroscopes has been developed by Sperry Gyroscope. Made of a bromine version of chlorafluorocarbon fluids, it remains viscous at —65°F, eliminates need of heating gyros during storage in arctic regions.

•

DuPont reports high effectiveness of fibrous potassium titanate as insulator in 1300° to 2100°F range. Firm is cutting prices of the lump form from $12 to $7.50 per lb.

•

Two-year program of Battelle Memorial Institute, sponsored by 16 firms, is studying new compounds, alloys, and techniques used in thermoelectric cooling devices.

The National Bureau of Standards has tested four of the "rare earth metals" in separate alloys with magnesium. Metals —lanthanum, cerium, praseodymium and neodymium — showed differences that had not been known before.

•

Rhenium, whose 5756°F melting point is only surpassed by tungsten and carbon, is being produced commercially through powder metallurgy by Chase Brass & Copper Co. Rhenium shows potential for increasing reliability of electronic missile components.

•

AVCOITE, first of a family of ceramic materials being developed by Avco Research and Advanced Development Div., has stood heat shock of 5,000°F for over 60 sec.

Internal oxidation of thin, cold-rolled solid solution titanium-cerium alloys results in improved strength at high temperatures over pure titanium. Army Ordnance experimentation is described in Office of Technical Services PB 131788.

•

High temperature synthetic lubricant oil for jet engines will withstand temperatures of 400°F for sustained periods. Developed by Celanese Corp. of America and ARDC's Wright Air Development Center, it improves range of lubricant operation by about 100°F.

•

Low cost cadmium coating process has been developed by NRC Equipment Corp. and its parent National Research Corp. It is reportedly an improvement over electroplating,

USE THIS NEW KIND OF DIAMOND CUT-OFF WHEEL

Gives narrower, smoother cuts on industry's toughest materials

. . . yet prices start at only $32.25

Now . . . at *production prices* . . . DIATRONIC gives you a rim width of .006" that's accurate to a maximum total tolerance of .0005"— or your money back. This accuracy is built in by a new process. No break-in needed. New narrow cut reduces sawdust loss 30%. A must for $3,000-a-pound silicon or germanium crystal. Cuts tungsten carbide, corundum, aluminum oxide, glass . . . practically anything. Stock orders shipped in hours; special wheels available. Write for literature, price list.

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PROSPECT . . .

cost and quality wise, protecting high tensile steel against corrosion without hydrogen embrittlement.

•

Evaluation of five powder metallurgy methods for fabricating beryllium shows that cold compacting followed by upsetting produces plate or sheet with optimum properties. Martin Co. did study for the Air Force, results available in Office of Technical Services PB 151-263.

•

New "SR" (super rust free) steels developed by Uniworld Research Corp. of America will be produced in alloy castings by Thompson Ramo Woolridge's Kolcast Div. Steels have high temperature and corrosion resistant qualities.

Molybdenum and columbium fasteners able to stand temperatures of 2,000°F may be expected this year, according to Standard Pressed Steel Co., Jenkintown, Pa., which also predicts steel fasteners with 300,000 psi tensile strength and titanium-alloy fasteners 20 per cent stronger than present bolts.

•

Chlorotrifluoroethylene polymers — developed commercially as result of the Manhattan project—are being used as lubricants in X-15 powerplant, also in compressors in Bomarc's ground support system. One reason is their high oxygen resistance. X-15 and Polaris use chlorotrifluoroethylene and bromotrifluoroethylene oils as flotation media for gyros and accelerometers in inertial systems.

Quartz threat has been developed by General Electric's Lamp Glass Department, Cleveland, O. Woven into cloth on textile equipment, it can be used to reinforce plastics in aircraft and missiles.

•

Clevite 300, new iron-base metallic compound, is now available for evaluation programs in sleeve bearing and seal applications. Developed by Cleveland Graphite Bronze Div., Clevite Corp., material has excellent thermal stability and anti-friction properties in moderate duty continuous service up to 1200°F.

•

Wolverine Tube, div. of Calumet & Hecla, is now producing extruded niobium tubing.

+
Electrolytic
Metal Removal
Potential
Unlimited
This new procedure has solved hitherto unsolvable problems, and greatly increased capacity and quality in virtually every application.
As pioneers in this very "young" development, we can offer you real help in licking hard metal removal problems, with actual installation and performance data. WRITE TODAY!
Missiles
Tool & Die Ind.
Automobiles
Aircraft
Results depend on the spindle used. There is nothing finer in its field than a STANDARD Super Precision Spindle . . . available for electrolytic application in 50 to 3000 Amperes.
THE
STANDARD
ELECTRICAL TOOL CO.
Precision Spindle Division
3000 River Road Cincinnati 4, Ohio
Now! Work hard metals without heat or distortion
Reduce wheel cost up to 90%
Circle 44 on Inquiry Card, page 81

NOW
AIRCRAFT TYPE
SWIVEL JOINTS
LOW TORQUE PLANE SWIVEL JOINT—
360° rotation in a single fixed plane.
NEW SELF-ALIGNING SWIVEL JOINT—
360° rotation plus 15° side flexibility.
BARCO Offers
Two Standard Types
Here are the newest designs in the field! SEND TODAY FOR BARCO CATALOG 269A. Since 1941 Barco Swivel Joints and special Flexible Assemblies have met the precise requirements of in-flight and other types of military equipment . . . conforming to MIL-J-5513A and other specifications. Barco's wide experience is yours to call upon in the development of your particular project — aircraft, missile, track vehicle or special installation — for hydraulic, pneumatic, oxygen, fuel, gas or liquid service. Barco Representatives are at your service in the specification of standard or specialized adaptations of standard designs.
BARCO MANUFACTURING CO.
565E N. Hough Street • Barrington, Illinois
Serving Industry Since 1908
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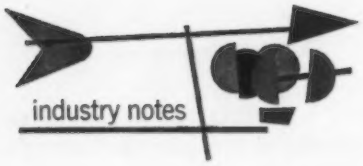


INDUSTRY STATISTICS

Source: Bureau of the Census and Civil Aeronautics Administration.

VALUE OF BACKLOG OF COMPLETE AIRCRAFT, AIRCRAFT ENGINES, AND PROPELLERS

All data are in Thousands of Dollars

Product and Type of Customer	December 31, 1958	September 30, 1958	June 30, 1958	March 31, 1958	December 31, 1957
Complete aircraft and parts					
For U. S. Military customers	$ 5,420,000	$ 5,349,000	$ 5,951,000	$ 6,470,000	$ 6,437,000
For other customers	2,690,000	2,759,000	2,697,000	2,672,000	2,799,000
Total	$ 8,110,000	$ 8,108,000	$ 8,648,000	$ 9,142,000	$ 9,236,000
Aircraft engines and parts					
For U. S. Military customers	$ 1,479,000	$ 1,730,000	$ 1,991,000	$ 2,129,000	$ 2,379,000
For other customers	539,000	566,000	565,000	602,000	590,000
Total	$ 2,018,000	$ 2,296,000	$ 2,556,000	$ 2,731,000	$ 2,969,000
Aircraft propellers and parts					
For U. S. Military customers	$ 47,000	$ 51,000	$ 69,000	$ 95,000	$ 126,000
For other customers	22,000	25,000	25,000	27,000	32,000
Total	$ 69,000	$ 76,000	$ 94,000	$ 122,000	$ 158,000
Total—For U. S. Military	$ 6,946,000	$ 7,130,000	$ 8,011,000	$ 8,694,000	$ 8,942,000
Total—Other customers	3,251,000	3,350,000	3,287,000	3,301,000	3,421,000
Other products and services	$ 2,865,000	$ 2,555,000	$ 2,424,000	$ 2,329,000	$ 2,168,000
Total—All Products	$13,062,000	$13,035,000	$13,722,000	$14,324,000	$14,531,000

NUMBER AND VALUE OF CIVIL AIRCRAFT SHIPMENTS

Month	Units 1959	Units 1958	Value in Thousands 1959	Value in Thousands 1958
January	665	582	$ 49,590	$ 63,249
February	.....	518	.....	67,515
March	.....	708	.....	38,417
April	.....	708	.....	48,677
May	.....	630	.....	37,616
June	.....	592	.....	26,421
July	.....	503	.....	41,587
August	.....	471	.....	30,776
September	.....	399	.....	24,401
October	.....	628	.....	49,328
November	.....	531	.....	34,881
December	.....	612	.....	37,672
Total	.....	6,882	.....	$500,540

AIRFRAME WEIGHTS OF CIVIL AIRCRAFT SHIPMENTS

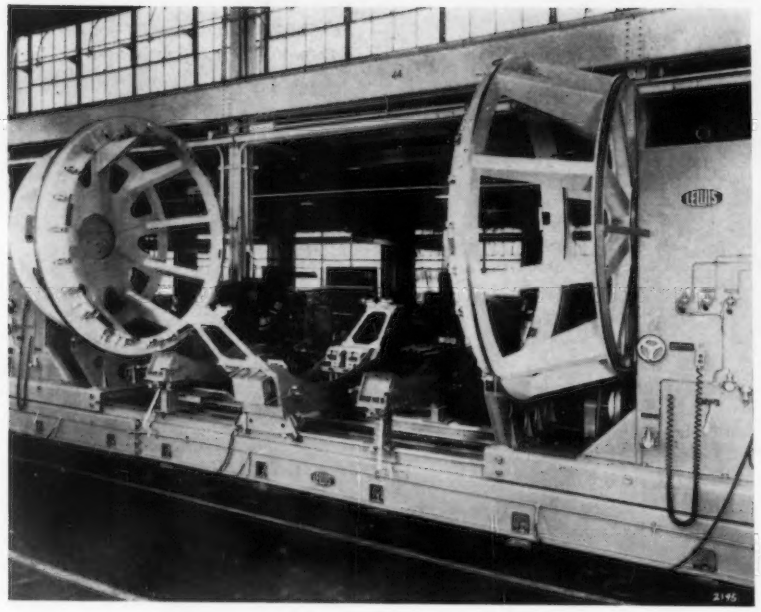
Month	Thousands of lbs. 1959	Thousands of lbs. 1958	Avg./Aircraft 1959	Avg./Aircraft 1958
January	1,452.8	1,932.0	2,185	3,320
February	.....	1,951.7	.....	3,768
March	.....	1,397.0	.....	1,973
April	.....	1,635.8	.....	2,310
May	.....	1,356.6	.....	2,153
June	.....	1,093.1	.....	1,846
July	.....	1,418.7	.....	2,820
August	.....	1,106.0	.....	2,348
September	.....	855.2	.....	2,143
October	.....	1,545.6	.....	2,461
November	.....	1,107.1	.....	2,085
December	.....	1,258.9	.....	2,057
Total	.....	16,657.7	.....	2,420

SHIPMENTS OF PISTON ENGINES FOR CIVILIAN AIRCRAFT

Month	Units 1959	Units 1958	Value 1959	Value 1958
January	873	1,033	$ 2,635,000	$ 8,883,000
February	.....	1,139	.....	9,696,000
March	.....	994	.....	8,174,000
April	.....	881	.....	8,174,000
May	.....	828	.....	6,176,000
June	.....	783	.....	5,994,000
July	.....	730	.....	4,898,000
August	.....	693	.....	3,420,000
September	.....	757	.....	3,312,000
October	.....	811	.....	3,336,000
November	.....	786	.....	2,815,000
December	.....	798	.....	2,965,000
Total	.....	10,233	.....	$ 67,843,000

TOTAL HP. OF AIRCRAFT PISTON ENGINE SHIPMENTS FOR CIVILIAN USE

Month	Total Hp. (in Thousands) 1959	Total Hp. (in Thousands) 1958	Avg. Hp. per Engine 1959	Avg. Hp. per Engine 1958
January	196.2	468.9	225	454
February	.....	518.2	.....	455
March	.....	440.7	.....	443
April	.....	428.0	.....	486
May	.....	338.3	.....	409
June	.....	328.7	.....	420
July	.....	282.1	.....	386
August	.....	210.0	.....	303
September	.....	214.0	.....	283
October	.....	220.9	.....	272
November	.....	198.6	.....	253
December	.....	201.7	.....	253
Total	.....	3,850.1	.....	376



WELDING A ROCKET CASING

Problem: design and manufacture a group of 75,000 lb automatic welding machines, each about the length of a railroad flatcar, for welding precision components for a solid fuel rocket engine casing.

The job tackled by The Lewis Welding & Engineering Corp. of Cleveland had all the stringent requirements of a Space Age order.

Machines would have to work on ultra-thin metals. This called for great delicacy of control in their operation.

The welding would be one of the last manufacturing procedures. If it resulted in a sub-standard weld, components for the casing would be so much scrap.

Machines were needed "with the utmost haste."

Lewis Welding, by now used to the "crash" need for new techniques for new weapons, got down to the design-production problem. Two huge clamp ring assemblies, half a story high, were built. These grasp the engine components at either end of a movable mandrel, rotating and adjusting them to exact welding and finishing locations. Near Swiss watch precision was achieved.

A few other examples of the problems faced by this and other welding firms: preheating thin components to 600°F for inert gas arc welding, preparing edges of parts for the welding, providing automatic cycle control for repeating the welding procedure with high reliability. The expanding field actually demands uniting of many physical sciences.

JET ENGINE COLD AIR STARTING SYSTEM

Introducing a new concept in engine starting equipment for jet aircraft, Wells Industries Corp., North Hollywood, Calif., has developed a jet engine cold air starting system for installation at airline terminals and overhaul bases.

Based on the proven "hydrant" system of aircraft refueling, the Wells system delivers relatively cold compressed air at pressures up to 110 psi and flows up to 200 lb per min to strategically placed hydrants.

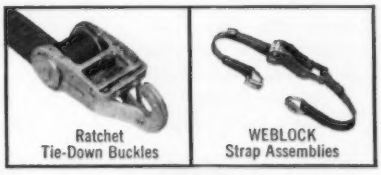
Aeroquip WEBLOCK Straps

SIMPLIFY HANDLING OF ROCKET THRUST CHAMBERS AT ROCKETDYNE

Thrust chambers are palletized for handling.

Use of Aeroquip WEBLOCK Strap Assemblies can solve many materials handling problems. At Rocketdyne, division of North American Aviation, Inc., a simple nylon strap harness was developed to secure top-heavy rocket thrust chambers on pallets. Harness attachment is quick and easy. Tension is automatically locked with a pull of the WEBLOCK Strap, released with finger touch.

Outline your aircraft or missile tie-down requirements and let General Logistics provide simple, low-cost answers. Mail coupon below for details.



Ratchet Tie-Down Buckles

WEBLOCK Strap Assemblies

General LOGISTICS
A DIVISION OF Aeroquip CORPORATION

2929 Floyd Street, Burbank, California
Please send information on: AMM-4
☐ Ratchet Buckle ☐ WEBLOCK Straps

NAME_____
TITLE_____
COMPANY_____
ADDRESS_____
CITY_____ STATE_____

Circle 46 on Inquiry Card, page 81

march 31-april 3
national aeronautic meeting
society of automotive engineers
hotel commodore, n.y., n.y.

◆

april 7-10
40th annual convention
and welding show
american welding society
international amphitheatre, chicago, ill.

◆

april 12-19
world congress of flight
las vegas, nev.

april 16-18
southwestern conference and
electronics show
institute of radio engineers
dallas, texas

◆

april 18-22
annual meeting
american society of tool engineers
schroeder hotel, milwaukee, wis.

◆

april 23
eastern regional meeting
institute of navigation
friendship international airport
baltimore, md.

april 23-24
ASME-SAM management conference
statler hilton hotel, n.y., n.y.

◆

april 28
technical conference
north texas section,
society of plastic engineers
adolphus hotel, dallas, texas

◆

april 29-may 1
conference of metals engineering
metals engineering div., american
society of mechanical engineers
albany, n.y.

◆

april 30-may 1
controllable satellites conference
american rocket society, M.I.T.
cambridge, mass.

◆

may 6-8
1959 electronic components confer-
ence, electronic materials conference
benjamin franklin hotel
phila., pa.

◆

may 25-28
fourth design engineering conference
american society of mechanical
engineers
convention hall, phila., pa.

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LINDE's NEW PLASMARC TORCH SERVICE

Brings Industry Production Parts From Refractory Metals

No other method of fabricating refractory metals can match this. . . . The high melting points of tungsten, tantalum, and molybdenum are no longer a problem. For LINDE's new *PLASMARC* Torch, working in the temperature range between 15,000 and 30,000 degrees K., can coat parts or form shapes of virtually any size or complexity. It's an entirely new way to make such articles as rocket nozzles, crucibles, components for electronic and X-ray use, and parts for atomic energy equipment!

The quality of these pieces is uniformly high. Tolerances can be held to ±.002 in. or better. The metal loses none of its purity and superior density is achieved.

With the *PLASMARC* Torch, LINDE is equipped to supply you with parts made of, or coated with, refractory metals; or made of a variety of metals combined with non-metals or reinforced plastics. LINDE will also provide a wind-tunnel materials testing service based on this device. For information on this extension of LINDE's well-known Flame-Plating service, write Dept. AW-13, LINDE COMPANY, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N.Y. In Canada: Linde Company, Division of Union Carbide Canada Limited.

The *PLASMARC* Torch employs a non-transferred electric arc to generate such high temperatures that powder or wire fed into the chamber is literally melted. Inert gases flowing continuously carry the metal particles in a plastic state and deposit them on the workpiece at near-sonic speeds. Jets of CO_2 cool the particles instantly to form heat- and erosion-resistant material. Coatings—even on graphite—have an excellent bond. Shapes are built up on machined mandrels, which are then etched away to leave parts such as those shown above.

Linde UNION CARBIDE

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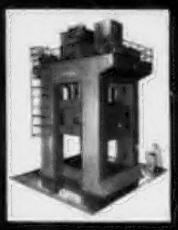
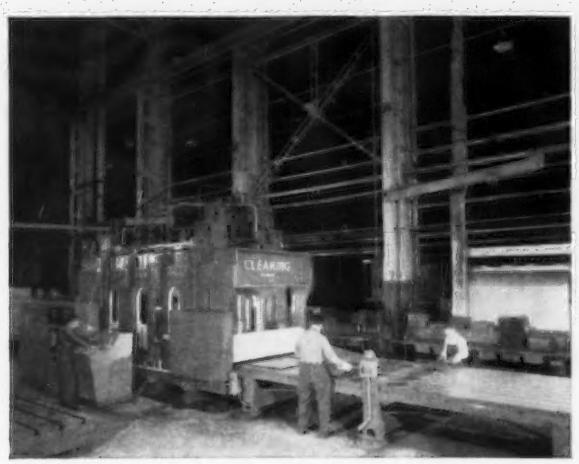
When it comes to Hydraulic Presses...

large or small

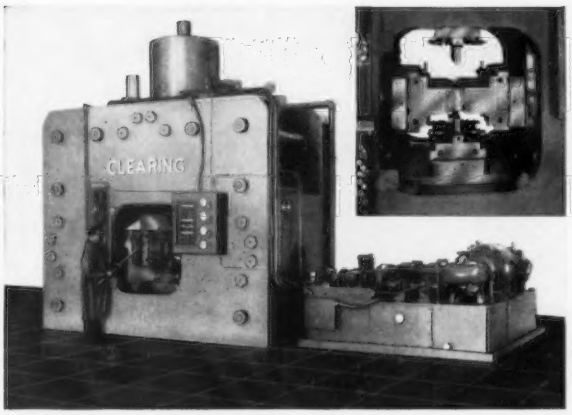


FOR ANY TYPE OF APPLICATION such as these metalworking drawing presses



WITH SPECIAL FEEDING EQUIPMENT as shown on this metal bonding machine

WITH ANY TYPE OF CONTROLS as seen on this rubber pad forming press



AND COMPLETE WITH THE TOOLING YOU NEED FOR THE JOB as we designed and built for this briquetting press

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There are no limitations on the type and size of hydraulic press equipment Clearing can design and build for you. No limitations either on the creative engineering you'll find at Clearing. Working with "new" metals—titanium, tantalum, columbium, uranium, zirconium?

Clearing will have a more productive answer for you. Investigating new processes and production techniques? Call on Clearing. You'll find a forward looking team of engineers that can work with you to solve your manufacturing problems effectively and economically.

Clearing, division of U. S. Industries, Inc. also manufactures power presses of all types, dies and special tooling, and special equipment for the aircraft and missiles industry.

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